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Formation of height increment of hybrid aspen in Latvia

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Abstract. Annual increment of hybrid aspen exceeds that of other tree species (including common aspen) in Baltic States. Notable (several-fold) differences in productivity between clones have been detected and therefore tree breeding programs are established to select the best genotypes (clones) for large-scale propagation. In order to aid the selection as well as understand the potential changes in growth of hybrid aspen as a result of climatic changes, it is important to analyse the intra-annual growth dynamics. Therefore aim of our study was to assess height growth intensity of hybrid aspen and factors affecting it. Weekly measurements of height increment were carried out through the third growing season of trees in two plantations, consisting of 19 clones (10 ramets per clone), on abandoned agricultural land in western (Mazirbe, 56° 36′ N, 24° 30′ E) and central (Vecumnieki, 57° 40′ N, 22° 19′ E) part of Latvia. Mean height growth period of hybrid aspen ranged from 119 ± 8.9 days for late flushing clones to 137 ± 8.6 days for early flushing and was tightly (r = 0.69) linked to total length of height increment. Mean height growth intensity during this period for respective groups of clones ranged from 7.7 ± 3.04 mm day^{-1} to 11.7 ± 2.93 mm day^{-1}. Growth intensity (and height increment) was significantly affected by genotype (clone) and in both sites tightly (r = 0.57…0.84) linked with daily mean temperature, but not with precipitation. Increasing temperature in future might boost the productivity of hybrid aspen plantations, especially with early flushing clones.

Key words: height growth intensity, growth period, *Populus tremula* × *P. tremuloides*.

INTRODUCTION

Hybrid aspen – a cross between two geographically isolated aspen species – has higher productivity than both of its parent species, as demonstrated by number of studies in Baltic Sea region countries (Liesebach et al., 1999; Johansson, 2002; Rytter & Stener, 2005). Wood fiber properties are important in determination of its suitability for paper production (Irbe et al., 2013) and hybrid aspen has the desired properties to be used as raw material in pulp and paper industry. Demand for wood as a renewable material is raising and it is predicted to ensure the market for fast-growing trees from plantations (Schueler et al., 2013).

Hybrid aspen clones (genotypes) have notably different increment and quality (e.g. stem straightness, branch angle). Breeding programs are established to test the materials and select clones with desired properties for particular climatic conditions (Stener & Karlsson, 2004). However, rapid changes of climatic conditions are predicted within this

century: rise of temperature, increase in length of vegetation period and frequency of extreme events (e.g. longer drought periods, storms) (IPCC, 2014). To predict, how these changes could affect productivity of hybrid aspen, it is important to understand the mechanisms triggering the growth onset and cessation as well as determining the increment. It is also important to assess clonal differences in these traits. This information could potentially be used in breeding programs to boost the productivity of plantations in future.

Hybrid aspen families have different bud burst time, growth period and annual increment (Ceulemans et al., 1987; Li &Wu, 1996; Li et al., 1998; Yu et al., 2001). Observed differences could be linked to different reaction to photoperiod and temperature that are important in determination of phenological processes and development of frost hardiness for trees (Rohde et al., 2010). Most of the studies so far have analysed inter-annual differences in meteorological conditions and reaction of trees; for example, survival, proportion of trees with frost damages, radial increment (dendrochronology), but only few have addressed the intra-annual growth in relation to meteorological conditions. Therefore aim of our study was to assess height growth intensity during the vegetation period of hybrid aspen and factors affecting it.

MATERIALS AND METHODS

Fenced plantations, including 19 hybrid aspen (*Populus tremula* × *P. tremuloides*) clones were established on abandoned agricultural land in western part of Latvia, Mazirbe (~2 km from Baltic Sea, 56° 36′ N, 24° 30′ E) and central part of Latvia, Vecumnieki (57° 40′ N, 22° 19′ E), using micro-propagated, containerized one-year old plants. During the 3rd growing season height of 10 ramets per clone was measured on average every 7th day (altogether 20 measurement times in Vecumnieki and 19 in Mazirbe) and average growth intensity (mm day^{-1}) calculated. Hourly data of meteorological conditions (temperature, precipitation) were collected, using portable weather stations, located just besides each of the trials.

During the active growth period (May – August) mean temperature was by ~ 1°C higher in Vecumnieki than in Mazirbe, the highest differences were observed in August: 1.9°C. Sum of precipitation in Vecumnieki in May was higher and in June lower than in Mazirbe (76 *vs.* 42 mm and 126 *vs.* 186 mm, respectively), but the total precipitation sum of the analysed period was almost equal in both sites.

Bud development and bud-burst phases were assessed in 6 grades (based on standard developed by UPOV, 1981) visiting the sites every second day, starting from the first signs of bud spring development (0 – dormant buds completely enveloped by the scales, 1 – buds swelling with scales slightly diverging showing a narrow yellow margin; presence of one or more droplets of balsam, 2 – buds sprouting, with the tips of the small leaves emerging out of the scales, 3 – buds completely opened with leaves still clustered together; scales still present, 4 – leaves diverging with their blades still rolled up; scales may be present or absent, 5 – leaves completely unfolded (but smaller in size than mature ones); lengthening of the axis of the shoot evident; scales absent). Length of the used growth period (days) was calculated for every measured tree from the bud burst till the end of height growth.

Data analysis was carried out using ANOVA, the mean values ± confidence intervals were calculated.

RESULTS AND DISCUSSION

Hybrid aspen clones were divided into three groups based on their bud burst phenology (Ceulemans et al., 1987): early, intermediate and late flushing. Distribution of clones in groups was similar in both sites – 7 clones were early flushing and 5 late flushing. Late flushing clones in both sites were significantly ($P < 0.05$) shorter (both height and height increment) than clones from other groups (Fig. 1). Length of height increment correlated tightly ($r = 0.69$) and significantly with the length of the used growth period. It indicates that longer growth period ensures accumulation of higher amount of nutrients and therefore higher net primary production (Barbaroux & Breda, 2002; Pallardy, 2008).

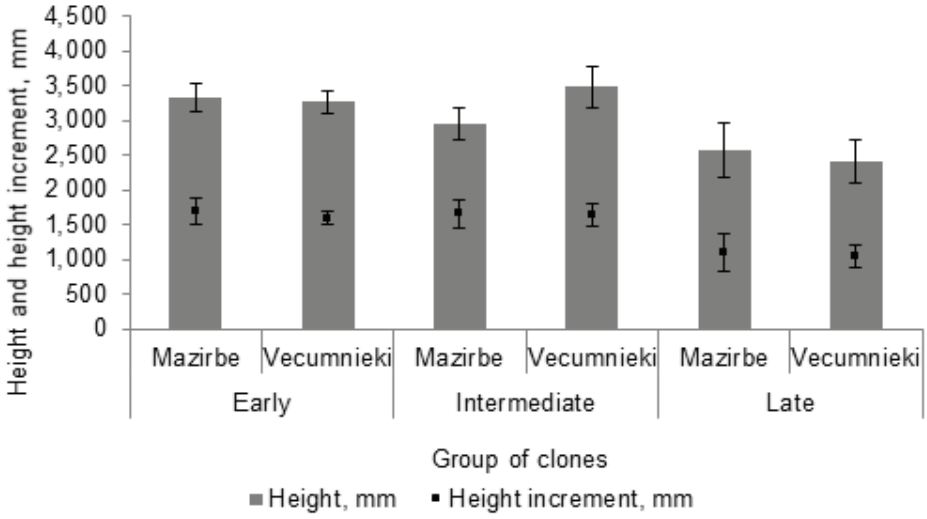


Figure 1. Height and height increment of early, intermediate and late flushing clones (mean values ± confidence interval).

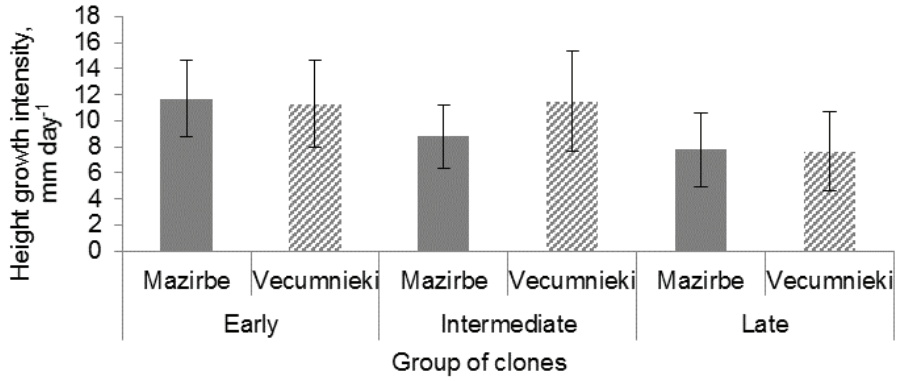
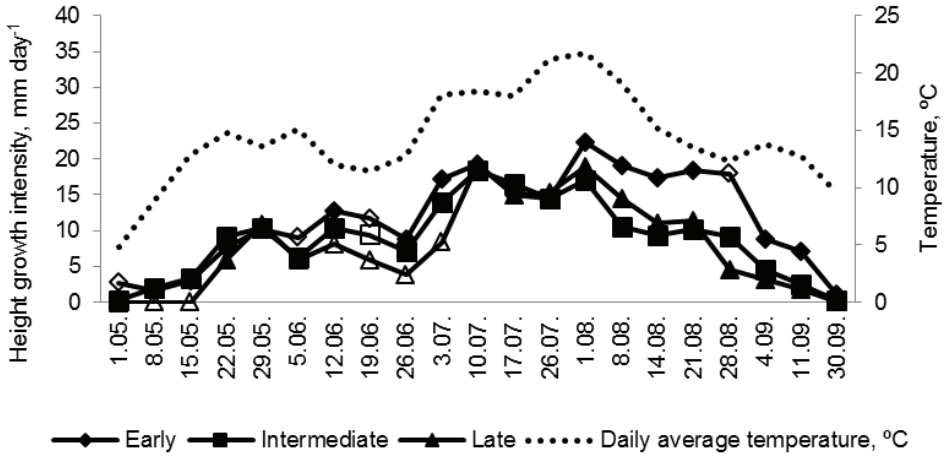


Figure 2. Mean height growth intensity of early, intermediate and late flushing clones (± confidence interval).

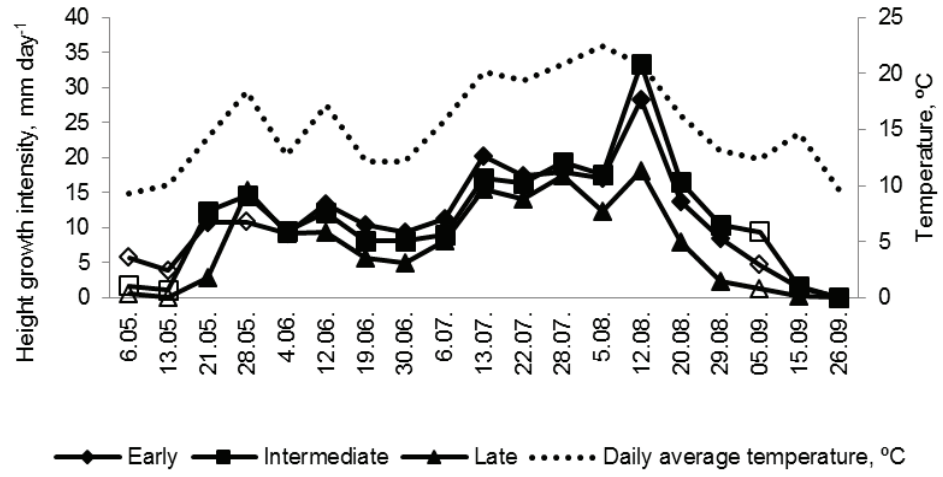
The longest used growth period was found for early flushing clones: 131 ± 3.60 days in Vecumnieki and 137 ± 8.6 days in Mazirbe.It was on average by 33 and 26 days shorter for intermediate and late flushing clones, respectively. Other studies have indicated, that early flushing clones might suffer from spring frost and that could negatively affect their height increment (Yu et al., 2001; Gu et al., 2008), but in our trials frost damages were not observed.

Mean growth intensity (mm day^{-1}) was slightly, but not significantly lower for late flushing clones than for clones from other two groups (Fig. 2).

Slight differences in growth intensity were found both between sites and between groups of clones within site (Fig. 3).



a)



b)

Figure 3. Height growth intensity of early, intermediate and late flushing clones in Mazirbe (a) and Vecumnieki (b).
Empty markers – growth intensity of particular group of clones in this date differs significantly ($P < 0.05$) from growth intensity of other groups of clones.

Late-flushing clones had slower start of the growth (until middle of May) and slower growth during the first part of the summer (middle of June – beginning of July). These differences were more pronounced in Mazirbe, than in Vecumnieki.

The largest (on average 7.5 mm day^{-1} in both sites) and in some of the observation periods also statistically significant differences in growth intensity between late flushing and both other groups (in Vecumnieki) or only early flushing (in Mazirbe) clones were observed at the end of growth period: from beginning of August until beginning of September.

Similar trend was observed also during previous growing seasons (Jansons et al., 2014) and indicates, that early-flushing clones in general have better ability to use the available resources effectively and produce higher increment. Influence of clone (genotype) on growth intensity and length of height increment was statistically significant. It is known from the studies of other tree species, that also meteorological conditions can have a significant influence on height increment (and growth intensity) of trees (Jansons et al., 2013 a, b). In our study in both sites tight (r = 0.57…0.84) and significant correlation between daily mean temperature and growth intensity was found. Influence of temperature on growth was higher for late flushing than for early flashing clones (in Mazirbe: r = 0.84 and r = 0.64, respectively). Lower reaction to fluctuations of meteorological conditions might be one of the reasons for better growth, observed for early flushing clones (Speer, 2010; Burton, 2012). Precipitation had no significant effect on growth intensity (r = -0.14….0.26), presumably because of sufficient water availability both from precipitation and ground water. In contrast, studies in central and southern part of Europe (in dryer conditions) have found strong influence of precipitation on both radial and height increment of trees. This influence partly depends on tree age (Carrer & Urbinati, 2006).

CONCLUSIONS

Mean height growth period of hybrid aspen ranged from 119 ± 8.9 days for late flushing clones to 137 ± 8.6 days for early flushing and was tightly (r = 0.69) linked to total length of height increment. Mean height growth intensity during this period for respective groups of clones ranged from 7.7 ± 3.04 mm day^{-1} to 11.7 ± 2.93 mm day^{-1}. It correlated significantly with daily mean temperature in a particular date.

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