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The influence of irrigation on the spruce (Picea abies) seedlings quality

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Introduction

The use of quality seedlings in reforestation programs has a major effect on forest plantation establishment, physiology, survival and growth (Margolis and Grand, 1990). Irrigation is among the cultural techniques that affect seedling quality, but are difficult to optimize in forest nursery practice. The unreasonable use of water, fertilizers and pesticides seriously endanger surface (Peepper et al., 1996).

In Lithuania Picea abies seedlings are usually planted in spring, when they are dormant and soil water is available. The planting period lasts usually for only 2 or 3 weeks (i.e. from the beginning to the end of May) before seedlings start to grow and soil is considered too dry for survival and growth (Paičius.J.2001). However, in May, soil temperature is often too low (< + 8° C) for root growth, as well as for uptake of water and nutrients by roots (Helenius et al., 2002).

The main objective of nursery irrigation is to avoid unwanted seedling moisture stress and its negative consequence for seedlings. The secret of effective nursery irrigation is to keep soil pores filled with the proper balance of water and air to minimize moisture stress (Morby, 1981).

Therefore, the objectives of this study were to (1) determine the irrigation regime for Picea abies seedlings and (2) to study the effect of different irrigation regimes on seedlings quality: height and steam diameter and survival.

Materials and methods

The field study was conducted in the period of 2002 - 2003. Seedlings were planted in Irrigation engineering department experimental fields at the Lithuanian University of Agriculture and in the "Dubrava" experimental forest nursery. Seedlings were grown under standard nursery cultural practices until being transplanted into new fields in mid April 2002. Seedlings had a height of 16 ± 5 cm (mean ± SE) and a steam diameter of 3 ± 0.6 mm at the time of transplanting.

75 spruce seedlings 2 + 0 were planted in the plots of 25 m2 each. 2 years seedlings grew in nursery from seeds, after that they were transplanted, and start new grooving period for next 2 years, after 4 years thy becomes 2+2 seedlings. There were three plots with three trials essay. Two irrigation treatments included a combination of soil water depth as thresholds for initiating irrigation and varying water application rates. At the variant 1 irrigation started, when the moisture of the 0.3 m soil layer reached 80 % of field capacity, in the variant 2 - 70 % of FC. The variant 3 - control. The norm of irrigation - 250 m3/ha.

The measurements of water content in the soil were conducted by sampling to a depth of 30 cm, with a division of the soil profiles in to 10 cm layers. The moisture percentage of the soil samples was measured gravimetrically. Seedling height and steam diameter were measured after planting, and after first and second growing season (September 2002 and 2003) http://www.lvmi.lt/).

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Growth conditions

In 2002 the mean temperature during the vegetation period was 2,2° C above the long-term average (+15° C). In the same period of 2003 mean daily temperature during the vegetation period was 0,7° C above the long tem average. The precipitation at 2002 was 233 mm (average -337 mm) and at the same period at 2003-301 mm.

In Lithuania the main moisture source is precipitation. Forest tree seedlings are most affected by soil moisture and it is the most important factor to get higher seedling quality (Duryea, Landis, 1984). In vegetation period precipitation distribution is very unequal and in the same periods of different years seedlings are affected soil moisture stress. For optimum spruce seedlings growth, soil moisture at 30 cm depth should be 80 % of field

capacity. At 2002, field No. 1 was irrigated 8 times, irrigation tare was 250 m3 water per hectare and seedling got 2000 m3 water per hectare. Field No. 2 was irrigated 6 times and seedlings get 1500 m3 of water per hectare. In 2003 year fields No. 1 and No. 2 were irrigated 4 times and seedlings get 1000 m3 of water per hectare. In 2003 precipitation was more intensive than in 2002 and seedlings got less water by irrigation.

The growth of seedling

All crops have moisture sensitive periods - times during witch water deficit depresses growth and survival more than it would be typically by expected (Baker and Ledgard, 1991). These critical periods are not well defined for forest tree seedlings. Plants are probably especially sensitive to moisture stress during bud break and early part of the linear growth phase in spring and during bud set and hardening in fall (Kramer, 1969). Seedlings height was measured 10 days after planting, on the 30 of April, and at the end of vegetation period both in 2002 and in 2003. The minimal steam height and steam diameter requirements were taken from new forest seedlings quality directives. After first growing season the minimum steam high requirement is 20 cm, stem diameter 4 mm, after second growing season - 25 cm and - 5 mm, respectively.

Survival of the transplanted rooted cuttings after the first growing season in variant 1 was 99 %; the same situation was fixed in variant 2. The seedlings growing in variant 3, were weak; the color of needle was not intensive. The most important reason for poor survival of seedlings was very dry and hot first growing season.

The statistical analyses were done with Microsoft Excel, data analysis - using descriptive statistics function. Confident level was used 95 %. Fig. 1 shows the distribution of seedlings height after second growing seasons.

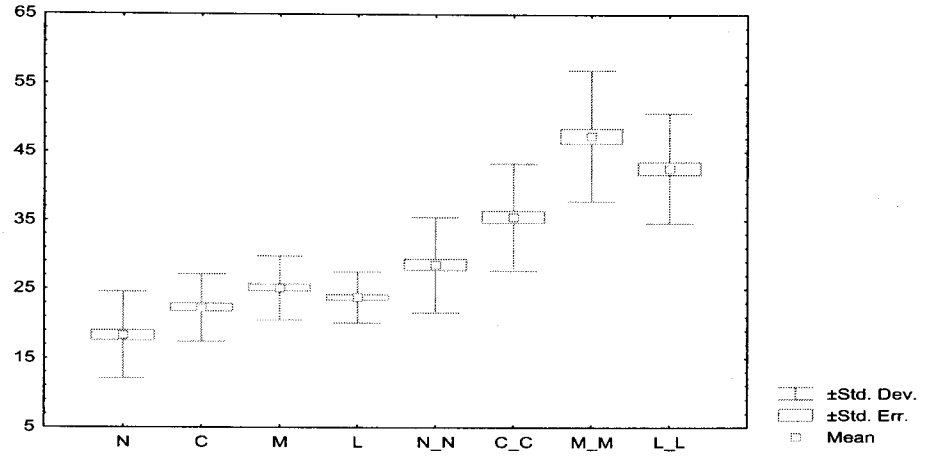

Fig. 1 The distribution of seedlings height cm.

Y-axis – steam height cm, X – axis seedlings growing variants. N-nursery planted seedlings (measurements made at 2002 autumn) N_N - 2003 autumn; C and C_C field No.3-; M and M_M – field No.1; L and L_L field No. 2.

It was established that after the first growing season (3 growing year) 69 % of seedlings in variant 1, and 64 % in variant 2, met the 20 cm height requirement for this growing season, and 5 % (8 % variant 2) of seedlings were higher than 30 cm. The mean height of seedlings after the first growing season was 22.5 cm; the increase of height was 7.1 cm. (5.6 cm variant 2). 85 % of seedlings stem diameter (90 % variant 2), met requirement 4 mm. The mean increase was 1.6 mm (1.8 variant 2). After the second growing season 97 % of seedlings satisfied the standards for this growing season. The mean height of seedlings was 44.9 cm, and the mean increment was 22.3 cm. All seedlings in both variants had steam diameter bigger than 5 mm. The mean of diameter was 8.2 mm; the increase of diameter was 3.4 mm.

61 % of seedlings, which were growing in natural conditions, variant 3, satisfied the standard requirement of 20 cm. The mean height was 22.3 cm, the mean increment – 5.8 cm. The mean stem diameter was 4.3 mm, the mean increment – 1.3 mm. After the second growing season the mean stem height was 35.5 cm,

the mean increment – 13.3 cm. 99 % of seedlings had stem diameter of 5 mm or more. The mean stem diameter was 7.5 mm, the mean increment – 3.2 mm.

Different situation was observed in "Dubrava" experimental field. The mean of height in "Dubrava" fields was 35.5 cm, in irrigated field - over 43 cm, the mean increment in "Dubrava – 10.1 cm in other fields - over 21 cm and in variant 3 - 13 cm. The situation with stem diameter index was similar: in "Dubrava – only 50 % of seedlings had diameter of 4 mm or more, in other variants 85 – 95 % seedlings. The mean diameter in "Dubrava was 3.8 mm, the mean increment – 0.9 mm, in other variants 1.3 - 1.8 mm. After the second growing season 88 % of seedlings were of good quality in nursery and other in other variants – 100 %. The mean diameter in "Dubrava was 7 mm, in other variants –7.5-8.6 mm, the mean of increment – 3.1 mm, in other 3.2-3.4 mm. Seedlings quality requirements are closely connected with financial aspects of nursery production. Bigger and stronger seedlings have bigger chance in forest after transplantation.

Conclusions

For optimum spruce seedlings growth, soil moisture at 30 cm depth should be above 80 % of field capacity.

Due to irrigation 97 % of seedlings after two - year growing season become higher than minimum quality demand. The mean stem height range from 43.6 cm till 44.9 cm in irrigated fields and 35.5 cm in field were seedlings grow in natural conditions and 28.2 cm in "Dubrava" nursery. The measurements of stem diameter show that 100 % of seedlings in irrigated fields, 99 % - in natural conditions field and 88 % - in nursery met the standard requirements.

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Summary

Potential growth of spruce seedlings (Picea abies) is highly dependent on the amount of applied irrigation and soil moisture. 75 Picea abies seedlings were planted per square in April 2002 in Irrigation engineering department experimental fields at the Lithuanian University of Agriculture, and in the "Dubrava" experimental forest nursery. Two irrigation treatments included a combination of soil water depth as thresholds for initiating irrigation and varying water application rates. Results indicate that for optimum spruce seedlings growth, soil moisture at 30 cm depth should average above 19 % of soil water content. In this case 97 % of seedlings after two-year growing season become higher than minimum quality demand. The measurements of stem diameters show that 100 % of seedlings in irrigated fields, 99 % in natural conditions field and 88 % in nursery to meet the requirements.

Keywords: soil moisture, seedlings, irrigation, steam height, steam diameter.

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