Project *brief*

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Coming from dry regions Norway spruce seedlings suffer less under drought

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- **Norway spruce seedlings from dry lowland regions as well as from southern provenance are more drought tolerant than those from German highland provenances.**
- **Early stress detection using biomarkers indicates the later mortality dynamics of seedlings under extreme drought well.**
- **Higher drought tolerance is, however, not linked to higher resistance of adult trees of the same provenance against biotic damages.**

Background and study aim

In the future German forests are likely to suffer more under extreme weather events like heat waves and drought accompanied by biotic threats, as experienced in the years 2018 to 2020. This is in particular true for drought sensitive Norway spruce stands. Thus, the risks maintaining to use the most common commercial tree species, spruce, will increase.

Within the cooperative project *spruce drought* (Fichte-Trockenheit) researchers studied drought tolerance in seedlings and adult trees looking for adapted provenances and individuals. The results shall reveal options to increase drought tolerance of spruce dominated forests.

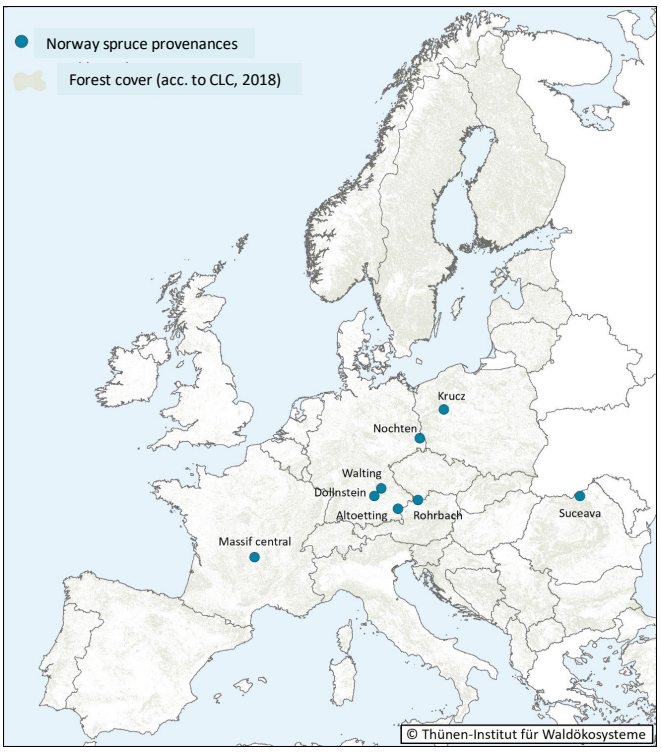
Figure 1: Dead and alive Norway spruce seedings at the end of the drought experiment

Source: M. Natkhin

Methods

Drought was applied to 960 two-year old Norway spruce seedlings from eight provenances in a greenhouse pot experiment (Figure 1, 2). One hundred seedlings of each provenance were dried out, twenty irrigated as a control.

Figure 2: Provenance origin of the Norway spruce seedlings used in the drought experiment



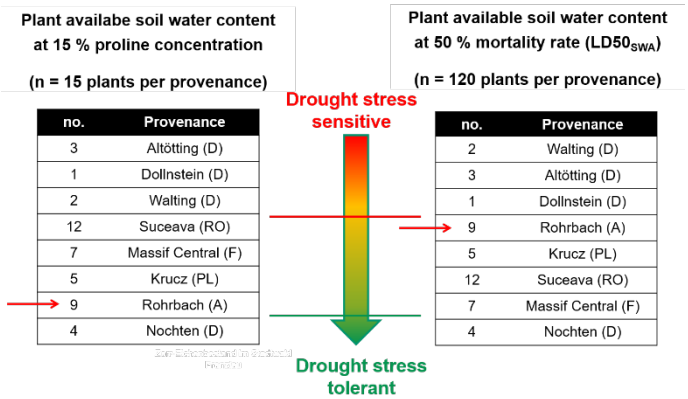
Source: Thünen Institute

Prior to the experiment we took plant material for genetic analyses. During drought treatment the effects of decreasing plant available soil water content on plant water status and performance were studied using following indicators: (1) pre-dawn water potential, (2) mortality rate, and (3) the concentration of plant substances in needles (biomarkers). In addition, we analysed wood anatomical traits of three seedlings per provenance like tree ring width, cell wall thickness, and resin conduits density to reveal variation in wood structure.

Results

During the application of drought stress differences of seedlings' drought tolerance became visible. Higher drought sensitivity occurred in seedlings from three higher elevated locations in Bavaria (Germany) with higher precipitation in the source region, compared to those from a lowland location with low precipitation in north-eastern Germany. The four other provenances from Poland, France, and Romania exhibited medium stress tolerance (Figure 3). Early detection of drought sensitivity by biomarker analyses correlated well with the later mortality dynamics of the spruce seedlings (except for the Austrian provenance Rohrbach, marked).

Figure 3: Comparison of drought stress indication using biomarker (prolin content, left) with the mortality dynamics (right), sequence according to drought sensitivity



no.	Provenance
3	Altötting (D)
1	Dollnstein (D)
2	Walting (D)
12	Suceava (RO)
7	Massif Central (F)
5	Krucz (PL)
9	Rohrbach (A)
4	Nochten (D)

no.	Provenance
2	Walting (D)
3	Altötting (D)
1	Dollnstein (D)
9	Rohrbach (A)
5	Krucz (PL)
12	Suceava (RO)
7	Massif Central (F)
4	Nochten (D)

Source: Thünen Institute

The wood anatomical analyses showed an increased resin conduit density of drought tolerant spruce seedlings compared to the drought sensitive ones. However, a correlation between wood anatomy and drought stress tolerance could not be proven due to a limit number of samples.

Conclusions

Norway spruce trees adapt to a certain content to site conditions at their original location while passing this adaptive potential on to their progenies. In case of the studied drought tolerance, young spruce originating from dryer environments exhibited an increased drought tolerance. Compared to other tree species like European beech the variation of drought tolerance among different provenances are, however, comparably low.

There is no indication that a higher drought tolerance of seedlings coincides with a higher resistance of adult trees to biotic agents like bark beetle (Figure 4). In line with this, bark beetles killed the provenance stand *Nochten* in north-eastern Germany. Seedlings from this provenance were the most drought tolerant in the experiment (Fig. 3).

Figure 4: Dead Norway spruce stand after bark beetle infestation.

Source: A. Bolte

Outlook

Studies on drought stress tolerance of seedlings and adult tress should be combined with those on biotic damages, in order to evaluate the interactive effects of drought and pathogen impacts against the background of genetic variation. The genetic characterisation methods established during this project can be used for evaluating varying drought tolerance and pathogen resistance on an individual basis. This will support novel approaches for drought and pathogen adaptation of forests under climate change.

Further information

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1730

Publications

Lautner S, Lenz C, Hammel J., et al. (2017) Using SRμCT to define water transport capacity in *Picea abies*. Proc. of SPIE, Vol. 10391 1039118-1, doi: 10.1117/12.2287221.

Liesebach H, Hartmann M, Liesebach M, Bolte A, (2018) Genetisch verankerte Reaktion der Fichten auf Trockenstress? AFZ-Der Wald 73: 13-15.

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