Thinning experiments in young Norway spruce stands affected by decline in the Czech Republic

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Introduction

Norway spruce (*Picea abies* L., Karst.), as the most important commercial tree species, occupies about 54% of forested area in the Czech Republic. This species is, however, also prone to suffer from many pests and harmful agents, especially in areas beyond its natural ecological conditions. In the last two decades, massive and chronic spruce stands decline has been occurred in the Czech Republic. The decline manifests itself by yellowing, defoliation and by dying of trees in all age stages. The main reasons are probably unsatisfactory state of forest soils due to former pollution deposition, precipitation deficiency and high temperature in vegetation seasons connected with global climate change. Honey fungus and bark beetle attacks should have been considered as just accompanying factors. Basically, cause of spruce decline lies in complicated complex of factors.

Thinning has been a common silviculture measure in young spruce stands in the Czech Republic. Nowadays, thinning strategy in the affected young spruce stands is questioned. Forest managers often give up thinning in declining stands due to fear of further deterioration of spruce health immediately after thinning. Properly conducted thinning in the young spruce stands (especially monocultures), however, is considered to be a prerequisite for improving both stability and vitality of individual trees and for making stand structure appropriate to introduction of other forest species. Experimental thinning program in young spruce stands started in 2010. The main objective of the experiments was to check out effects of intensive thinning of young spruce stands on their health, increment and static stability development.

Methods

Three experiments lie in northeastern part of the Czech Republic, one of the most affected areas exhibiting the spruce decline today. Altitude of the selected stands ranged from 400 to 450 m above sea level. Mean annual precipitation in area ranged from 500 to 690 mm. The soil type is identified as cambisol. Preliminary soil analysis showed low content of basic cations, especially calcium. Experiment in ten years old spruce monoculture originated from natural regeneration was founded in 2010. Six square plots (0.01 ha) were founded in completely randomized design. Initial density of the stand ranged from 22 000 to 36 000 trees per hectare. Mean height of dominant trees was approximately 5-6 m. The thinning measure (in three plots) consisted in selection of 1500 healthy trees per hectare, more or less regularly distributed across plots. These “target trees” were considered a stable and economically prospective part of future forest stand. The other trees were removed. Three plots were kept as a control with no-thinning treatment.

Similarly, two experiments in 14-17-year old spruce dominated stands originating from artificial regeneration were founded in 2010. Eight square plots (0.04 ha) were founded in randomized block (a pair consist of a thinned and a control plot) design. Initial density of the stand ranged from 2 400 to 4 600 trees per hectare. Mean height of dominant trees was approximately 7-9 m. Norway spruce dominated, but European larch, Scots pine and European beech also occurred in the stands. The thinning measure consisted in selection of 1000 healthy trees per hectare, more or less regularly distributed across plots. In some circumstances, small number of vigorous European larch trees was also selected as “target trees”. The other trees were removed with exception of vigorous small (up to 2 m height) beech in the mixture.

In control treatment, the same number of “target trees” were selected. Health status, diameter and height of “target trees” were monitored annually at the end of growing season.

Mean annual increments and relative mean annual increments were analysed by ANOVA, health condition (portion of healthy “target trees” and mortality) was analyzed by generalized linear model with binomial distribution and logistics link function.

Results and discussion

Thinning led to acceleration of diameter increment of “target” spruce trees compared to control treatment in both thicket (T) and small-pole (SP) stands. Mean annual increment of diameter was about 0.3 cm higher in thinned treatment (p-value = 0.02) equally in T and SP stands. Mean height increment was slightly higher in thinned treatment in T and slightly lower in SP stands. Negative differences of slenderness quotient four years after thinning were observed in all thinned plots (from -4 to -18), while differences of slenderness quotient ranged from -2 to +7 in control plots (tab. 1, tab. 2).

Our results is in accordance with results of other authors. For example, Kuliešis and Saladis (1998) found in eleven-year-old experiment with Norway spruce the best diameter increment in treatments where 1200-2400 trees per hectare remained. Štefančík (2012) on the basis of thinning experiment in 21 year old Norway spruce stand in Slovakia, concluded that intensive thinning (1 100-1 600 trees remained) led to better diameter increment and stability of remained trees.

Tab. 1: Mean stem parameters of “target” spruce trees in thicket from natural regeneration

Plot	D[1] (cm)	H[2] (m)	H/D[3]	D (cm)	H (m)	H/D	iD[4] (cm)	riD[5]	iH[6] (m)	riH[7]	diff H/D[8]
	Year 2010			Year 2014							
1 Control	6.8	6.4	94	9.1	8.3	92	0.6	0.07	0.5	0.07	-2
2 Control	5.7	5.6	97	7.3	7.4	100	0.4	0.06	0.4	0.07	4
3 Control	7.2	6.3	88	9.5	8.4	89	0.6	0.07	0.5	0.07	1
4 Thinned	5.5	5.4	98	9.5	7.7	80	1.0	0.14	0.6	0.09	-18
5 Thinned	5.6	5.3	95	8.8	7.4	84	0.8	0.11	0.5	0.08	-11
6 Thinned	5.9	4.8	81	9.1	7.1	78	0.8	0.11	0.6	0.10	-4

1 – stem diameter; 2 – height of mean stem; 3 – quotient of slenderness; 4 – mean annual increment of diameter; 5 – relative mean annual increment of diameter; 6 – mean annual increment of height; 7 – relative mean annual increment of height; 8 – difference in slenderness quotient after four years

Tab. 2: Mean stem parameters of "target" spruce trees in small-pole stands from artificial regeneration

	$D^{1)}$ (cm)	$H^{2)}$ (m)	$H/D^{3)}$	D (cm)	H (m)	H/D	$iD^{4)}$ (cm)	$riD^{5)}$	$iH^{6)}$ (m)	$riH^{7)}$	diff $H/D^{8)}$
Plot	**Year 2010**			**Year 2014**							
I Control	8.9	7.8	88	10.5	9.8	93	0.4	0.04	0.5	0.06	6
I Thinned	10.6	8.1	77	13.5	9.5	70	0.7	0.06	0.3	0.04	-6
II Control	9.2	7.9	86	11.6	9.8	85	0.6	0.06	0.5	0.06	-1
II Thinned	8.9	7.6	86	12.1	9.3	76	0.8	0.08	0.4	0.05	-9
III Control	9.1	8.1	89	11.1	10.7	96	0.5	0.05	0.6	0.07	7
III Thinned	9.2	7.6	83	13.4	9.7	72	1	0.09	0.5	0.06	-10
IV Control	9.3	7.2	77	12.3	9.5	77	0.7	0.07	0.6	0.07	0
IV Thinned	10.1	8.6	85	13.7	11.0	80	0.9	0.08	0.6	0.06	-5

1 – stem diameter; 2 – height of mean stem; 3 – quotient of slenderness; 4 – mean annual increment of diameter; 5 – relative mean annual increment of diameter; 6 – mean annual increment of height; 7 – relative mean annual increment of height; 8 – difference in slenderness quotient after four years

Percentage of healthy spruce trees (without symptoms of yellowing) ranged from 47 to 60 % in control plots and from 60 to 73 % in thinned plots in T stand. In SP stands, percentage of healthy spruce trees ranged from 37 to 62 % in control plots and from 39 to 47 % in thinned plots (Fig. 1). Mortality four years after thinning was about 8 % higher (p-value = 0.24) in thinned treatment in T stand and about 10 % higher (p-value = 0.004) in thinned treatment in SP stands.

Slodičák and Novák (2004) found out temporary deterioration of health in young spruce stands five years

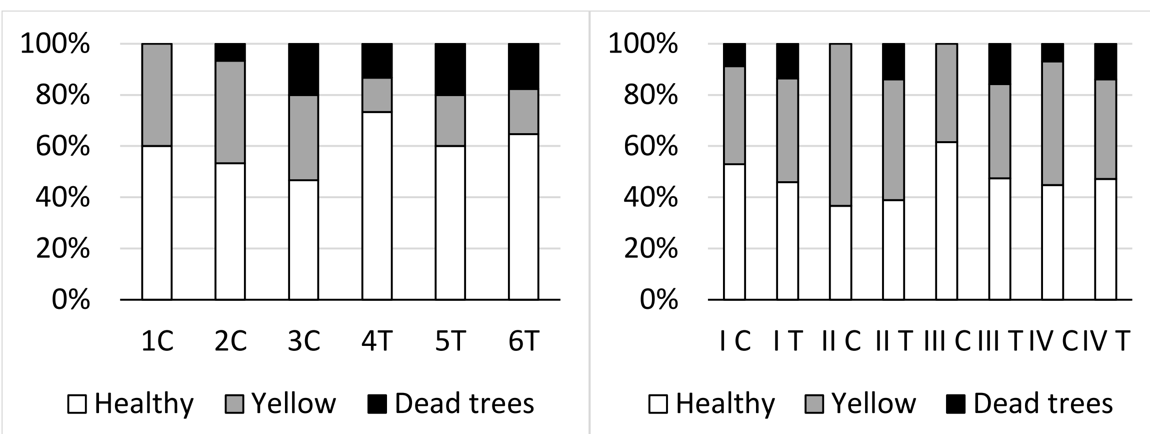

Fig. 1: Percentage of healthy, yellow and dead trees in thicket stand (left) and small-pole stands (right). Only „target" spruce trees are depicted. C – control treatment, T – thinned treatment.

after thinning in forests affected by emission deposition. However, in the long period, health of thinned treatments become well compared to unthinned control treatment.

Conclusion

The thinning led to higher diameter increment of “target trees” compared to control treatment in stands originated from both natural and artificial regeneration. The height increment was not substantially influenced by thinning. Consequently, we observed favorable development of slenderness quotient in thinned treatment compared to control one. Sufficiently low slenderness quotient is a prerequisite for better resistance of trees and stands against harmful effects of snow and wind in the future. Moreover, sparse stand density is a prerequisite for introduction of other tree species by both natural and artificial regeneration.

The effect of thinning on health of spruce remains unclear. In older stands originated from artificial regeneration we observed statistically significant higher mortality in thinned plots. On the other hand, number of healthy “target” spruce trees per hectare in all plots is still sufficient to ensure fulfillment of required economical and ecological functions of forests. Since near natural species forest composition is an objective of forest management at present, we consider min. 300 – 400 healthy spruce trees per hectare as sufficient in spruce small-pole stand.

We can conclude that thinning in young Norway spruce forest is tenable and useful measure even in the stands affected by new decline symptoms.

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Literature

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