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Effect of thinning and reduced throughfall in young coppice dominated by *Quercus petraea* (Matt.) Liebl. and *Carpinus betulus* L.

Einfluss der Durchforstung und Niederschlagsreduktion auf einen jungen Ausschlagswald mit dominierender Traubeneiche (*Quercus petraea* (Matt.) Liebl. und Hainbuche (*Carpinus betulus* L.)

Barbora Fedorová [1*], Jan Kadavý [1], Zdeněk Adamec [1], Robert Knott [2], Aleš Kučera [3], Michal Kneifl [1], Karel Drápela [1], Romà Ogaya Inurrigarro [4]

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Abstract

The effects of thinning and reduced throughfall on soil moisture and the diameter and height increments of sessile oak and European hornbeam sprouts were studied in the southeastern part of the Czech Republic. Thinning was performed by reducing the basal area by 50% in each stool. Reduced throughfall (a reduction of 30%) was achieved by constructing parallel drainage channels. Diameter and height incre-

[1] Department of Forest Management and Applied Geoinformatics, Mendel University in Brno, Zemědělská 1, 613 00 Brno, Czech Republic,
*Corresponding author: Barbora Fedorová (barbora.fedorova@mendelu.cz)
[2] Department of Silviculture, Mendel University in Brno, Zemědělská 1, 613 00 Brno, Czech Republic
[3] Department of Geology and Pedology, Mendel University in Brno, Zemědělská 1, 613 00 Brno, Czech Republic
[4] Centre de Recerca Ecològica i Aplicacions Forestals (CREAF), Edifici C, Campus de Bellaterra, 08193 Cerdanyola del Vallès, Barcelona, Spain

ments and soil moisture were measured. Reduced throughfall had no statistically significant effect on the diameter relative growth rate (RGR) of sessile oak and European hornbeam one year after thinning. However, thinning had a statistically significant effect on the diameter RGRs of sessile oak and European hornbeam. The height RGRs of sessile oak and European hornbeam were not influenced by thinning and reduced throughfall. Soil moisture was statistically significantly affected only by thinning. The reduced throughfall and the available water capacity reduced by the stoniness and thickness of the soil genetic horizon (AWC_{red}) was used as a covariate had no significant effects on soil moisture. The effect of thinning on the diameter RGR was statistically significant for both studied species. The effect of thinning on soil moisture was statistically significant. Currently, published data on the effect of reduced throughfall on oak-hornbeam coppice in Central Europe are unique.

Zusammenfassung

Die Auswirkungen einer Durchforstung und eines reduzierten Niederschlags auf die Bodenfeuchte und auf den Durchmesser- und Höhenzuwachs der Traubeneichen- und Hainbuchenausschläge wurden im südöstlichen Teil der Tschechischen Republik untersucht. In der Durchforstung wurde die Grundfläche jedes Büscheln um 50% reduziert. Die Niederschlagreduzierung (eine Reduktion von 30%) wurde durch den Bau von parallelen Entwässerungskanälen erreicht. Durchmesser- und Höhenzuwachs und Bodenfeuchte wurden gemessen. Der reduzierte Niederschlag hatte keine statistisch signifikante Auswirkung auf die relative Zuwachsrate (RGR) von Traubeneiche und Hainbuche ein Jahr nach der Durchforstung. Allerdings hatte die Durchforstung eine statistisch signifikante Auswirkung auf die relative Durchmesserzuwachsrate von der Traubeneiche und Hainbuche. Die relative Höhenzuwachsrate der Traubeneiche und Hainbuche wurden nicht durch die Durchforstung und den reduzierten Niederschlag beeinflusst. Die Bodenfeuchte wurde nur durch die Durchforstung statistisch signifikant beeinflusst. Die Niederschlagreduktion und die durch die Steinigkeit und die Dicke des bodengenetischen Horizonts (AWC_{red}) reduzierte verfügbare Wasserkapazität hatten keinen signifikanten Einfluss auf die Bodenfeuchte. Der Einfluss der Durchforstung auf die relative Durchmesserzuwachsrate war für beide untersuchten Holzarten statistisch signifikant. Der Einfluss der Durchforstung auf die Bodenfeuchte war statistisch signifikant. Derzeit sind veröffentlichte Daten über die Wirkung des reduzierten Niederschlags auf Traubeneichen-Hainbuchen-Ausschlagwald in Mitteleuropa einzigartig.

1. Introduction

Historically, in Central and South Europe, human interventions in coppice stands were not usually carried out during rotation periods, mainly because of economic reasons (Cañellas et al. 2004). In light of new findings, especially in the Mediterranean area, it now seems reasonable to carry out thinning (reducing the number of sprouts per stool) during rotation periods in coppices due to global climate change

(Bréda et al. 1995; Espelta et al. 2003; Cotillas et al. 2009). In this regard, the amount of water available (rainfall) is crucial for the successful growth and development of the coppice. Sessile oak (*Quercus petraea* (Matt.) Liebl.) has high edaphic and environmental moisture requirements (Rodriguez-Campos et al. 2010), so selective low thinning might be desirable. The most important fact is that soil moisture increases after thinning, and thus, more water is available for remaining sprouts (Cotillas et al. 2009). It seems that thinning may possibly eliminate the negative effects of drought on the growth and development of coppice.

In Europe, significant extremes in climatic characteristics (heat waves, drought and heavy rainfall) are forecasted. Hot days, tropical nights and heat waves will become more frequent, and frosty days will occur less often (IPCC 2014; Brázdil et al. 2015). All of these changes will affect the availability of soil water (Trnka 2009), resulting in changes in the growth and health condition of trees. The combination of higher radiation, higher air temperature, higher potential evapotranspiration and earlier growing season onset will lead to faster depletion of water reserves in the soil. According to the forecasts of Choat et al. (2012); IPCC (2014) and Brázdil et al. (2015), reduced rainfall will be a big issue in forestry. Information for developing new management strategies to mitigate the predicted negative effects of climate on forest growth is necessary. Coppice might be a suitable management alternative for extreme sites and sites where there will be reduced water availability (Pietras et al. 2016; Stojanović et al. 2016).

Sessile oak is a mesophilic tree species with a deep root system and that prefers semi-shady conditions. During periods of drought, leaf water potential is reduced, potentially leading to xylem cavitation. *Quercus robur* L. (pedunculate oak) is more sensitive (Timbal, Aussenac 1996). The diameter increment of oak is significantly affected by summer rainfall, especially in June and August. In contrast, high totals in January have a negative effect on the increment. Oak growth is significantly affected by the weather in the autumn of the previous year (Brázdil et al. 2015). European hornbeam (*Carpinus betulus* L.) is a half-shade-tolerant tree species. The drought tolerance of this tree species is high (Bredemeier et al. 2011).

In the Czech Republic, the impact of reduced throughfall on tree growth in coppice stands has not yet been studied. Our results come from a pilot project where the objective was to monitor long-term issues. According to the authors, the project is considered to be unique for the Czech Republic.

The main objectives of this article are to test the effects of thinning and reduced throughfall on (i) diameter increment of oak-hornbeam coppice, (ii) height increment of oak-hornbeam coppice and (iii) soil moisture.

2. Materials and Methods

2.1 Study area

The research was carried out in the territory of the Training Forest Enterprise "Masaryk Forest" Křtiny in the forest district Bílovice, in the southeast part of the Czech Republic. The elevation of research plots was 323 m a.s.l., with prevailing west and northwest slopes and 5-10° inclination. The soil at the study site is classified as Cambisol on a bedrock of granodiorite with an admixture of Devonian and Quaternary sediments in the upper part of the solum. The studied area belongs to the nutrient-medium beech-oak stand forest type with *Galium rotundifolium* (Viewegh et al. 2003). The study site is a seven-year old coppice stand, and it is dominated by sessile oak (*Quercus petraea*) and European hornbeam (*Carpinus betulus*) with a minor admixture of European beech (*Fagus sylvatica* L.), silver birch (*Betula pendula* Roth), wild cherry (*Prunus avium* L.) and wild service tree (*Sorbus torminalis* (L.) Crantz).

2.2 Meteorological data

According to the 2015 data from the climatic station in the study area, the mean air temperature and precipitation totals during the growing season (1 April-30 September) were 16.3°C and 311.0 mm, respectively, and there were 58 days with precipitation. During the growing season of 2014 (1 April-30 September), the mean air temperature was 15.4°C, the total precipitation was 500.8 mm, and there were 81 days with precipitation. Meteorological data were analysed in Mini32 Software (EMS, Brno, Czech Republic).

2.3 Experimental design and field measurement

The research area (0.5 ha) had a rectangular shape (40 × 125 m). It was stabilized in the terrain and fenced, and the surrounding areas were classified as protection zones. The research area was divided into rectangles, and each rectangle contained a circular plot with a radius of 5 m where quantitative and qualitative characteristics were measured (Table 1). A 14-metre-wide buffer zone was placed between each two neighbouring circular plots. The conditions of the forest stands were recorded by the same individuals before and after the planned interventions. The research area was established in 2008 (Kadavý et al. 2011), and its overall characteristics are presented in Table 1.

Diameter, height and number of sprouts per stool were monitored at the beginning and the end of the 2015 growing season.

Sprouts thicker than 1 cm were tagged. Diameters were measured at a height of 50 cm using a digital calliper in two directions perpendicular to each other and then averaged. Horizontal lines were marked on the sprouts to ensure comparable consecutive diameter measurements. The height of the highest sprout in each stool was measured using a telescopic rod.

Diameter and height increments were transformed into relative growth rates (RGR) so that growth rates could be compared among species and individuals who differed considerably in size. RGR is calculated as:

$$RGR_{x_i - x_{i-1}} = \frac{x_i - x_{i-1}}{x_{i-1}} * 100\ [\%] \quad (1)$$

where x_i is the value of the selected variable (diameter or height) in year i (in our case the end of the vegetation season 2015), and x_{i-1} is the value of the selected variable in the previous year (the beginning of the vegetation season 2015) (Cotillas et al. 2009).

Thinning was carried out in the winter of 2014/2015 by hand saw at ground level on the half of rectangle plots. The basal area of each stool was reduced to 50% in rectangles subjected to thinning by leaving 1-3 dominant sprouts per stump for sessile oaks and 1-4 dominant sprouts per stump for European hornbeam.

On two research plots (one thinned and one unthinned), parallel drainage channels (Figure 1) were installed in the winter of 2014/2015 to reduce the throughfall. The drainage channels were positioned 50-70 cm above ground level and covered 30% of the rectangles (10 × 15 m). All other plots received natural throughfall.

For each research plot average values of diameter and height RGR were calculated. These values were taken as basic characteristics of the plots and were used as variables in statistical analyses.

An automatic climatic station (EMS, Brno, Czech Republic) was set up in 2014 at an open place on the experimental site. Air temperature and precipitation data were acquired every hour and were stored in data loggers.

Soil moisture was measured every three weeks at a depth of 5 cm with an SM300 Soil Moisture Sensor (HH2 Moisture Meter – Readout Unit – Delta-T Devices, Cambridge, United Kingdom) and at depths of 10, 20, 30 and 40 cm (three 40-cm-long probes per plot were permanently installed) with PR2 Profile Probe (Delta-T Devices, Cambridge, United Kingdom). For each treatment and at each measured soil depth, the available water capacity (AWC, reduced by volume of stoniness and thickness of soil genetic horizon, is expressed as AWC_{red}) (Constantini et al. 2009) was assessed by analysing undisturbed soil samples using the following equation:

$$AWC_{red} = (RWC - WP) * s * h \text{ [mm]} \quad (2)$$

where RWC is retention water capacity (24 hr of free draining after thorough saturation) in % by volume; WP is wilting point in % by volume; s is (100 – stoniness of horizon in % by volume)/100; and h is thickness of horizon in dm.

Table 1: Basic characteristics of the research plots before thinning (standard deviation is in parentheses)

Tabelle 1: Die Grundmerkmale der Forschungspläne vor der Durchforstung (Standardabweichung ist in den Klammern angegeben)

No.	Thinning	Reduced throughfall	Species share*		Hg		Dg**		N		G**
			SO (%)	EH (%)	SO (m)	EH (m)	SO (cm)	EH (cm)	stools (pcs)	sprouts (pcs)	(m²)
1	no	no	89	11	3.4 (0.7)	4.1 (0.3)	3.5 (1.0)	3.3 (0.8)	3 514	8 936	10.2
2	no	yes	75	17	3.1 (0.7)	3.6 (0.7)	2.9 (1.0)	2.8 (1.1)	4 048	9 929	8.7
3	yes	no	79	16	2.7 (0.6)	3.7 (0.7)	2.8 (1.0)	3.2 (0.5)	3 514	8 096	6.7
4	yes	yes	75	17	2.8 (0.7)	3.2 (0.7)	2.8 (1.0)	2.2 (0.7)	4 736	9 395	6.8
5	no	no	10	89	4.7 (0.7)	4.6 (0.8)	6.2 (1.0)	3.9 (1.0)	1 681	6 416	8.8
6	no	no	12	88	4.0 (0.6)	4.8 (0.7)	4.1 (0.9)	3.8 (0.6)	1 375	8 707	10.1
7	yes	no	11	87	4.3 (0.5)	4.4 (0.8)	4.3 (0.8)	3.6 (1.1)	2 291	8 326	10,0
8	yes	no	49	50	4.1 (0.6)	4.3 (0.8)	4.4 (1.3)	3.4 (0.7)	2 291	9 700	11.9

SO: sessile oak; EH: European hornbeam; Hg: mean height; Dg: quadratic mean diameter; N: number of stools/sprouts per ha; G: basal area per ha; * calculated from G; and ** at 0.5 m above the ground

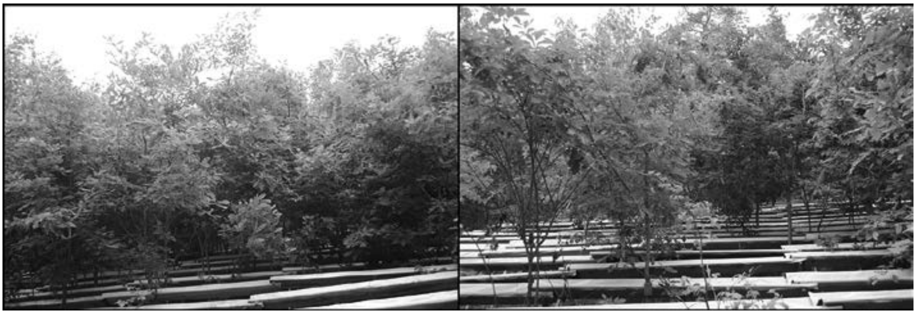

Figure 1: View of the plots with reduced throughfall: an unthinned plot is seen on the left, and a thinned plot is seen on the right (photo by Barbora Fedorová)

Abbildung 1: Der Blick auf die Versuchflächen mit reduziertem Niederschlag: links eine Versuchsfläche ohne Durchforstung, rechts eine Versuchsfläche nach der Durchforstung (Foto von Barbora Fedorová)

2.4 Statistical analyses

Due to small sample size (only 8 research plots) nonparametric statistical analyses were used. The effects of thinning and reduced throughfall on diameter and height RGR were analysed using a Mann Whitney U test. For the comparison of RGRs of sessile oak and European hornbeam against each other, a Mann Whitney U test was performed too. The effects of thinning and reduced throughfall respectively on soil moisture in research plots were tested using analysis of covariance (ANCOVA) with AWC_{red} as a covariate. All tests were analysed at the 0.05 significance level. Statistical analyses were carried out in STATISTICA 12 (Statsoft, Oklahoma, United States of America).

3. Results

3.1 Diameter increment

Reduced throughfall had no statistically significant effect on the diameter RGR of either sessile oak or European hornbeam (Table 2). The diameter RGR was similar in plots with reduced and normal throughfall in variants with thinning as well as in those without thinning (Table 3). Thinning had a statistically significant effect on diameter RGR of sessile oak and European hornbeam (Table 2). Thinned plots had significantly higher mean values of diameter RGR than those of unthinned plots for both tested tree species and for both reduced and normal throughfall variants. The diameter RGR of sessile oak in thinned plots with reduced throughfall was 56% higher than that in unthinned plots and 49% higher in thinned plots with normal throughfall than that in unthinned plots. In European hornbeam, diameter RGR was 52% higher in thinned plots with reduced throughfall than in unthinned plots and 93% higher in thinned plots with normal throughfall than in unthinned plots.

For the comparison of diameter RGR between sessile oak and European hornbeam, the effect of reduced throughfall was not considered due to the insignificant Mann Whitney U test results for both species. The species comparison was done only for the effect of thinning. Differences between the diameter RGRs of sessile oak and European hornbeam were statistically insignificant for thinned and unthinned plots (Table 4, Figure 2). Mean values of diameter RGR were 19.7% for thinned plots and 13.1% for unthinned plots of sessile oak and 20.6% for thinned plots and 11.3% for unthinned plots of European hornbeam.

Table 2: Effects of thinning and reduced throughfall on diameter and height RGR

Tabelle 2: Einfluss der Durchforstung und des reduzierten Niederschlags auf die relative Durchmesser- und Höhenzuwachrate

	U value	p value
Diameter RGR of sessile oak (ET)	1	0.0433
Diameter RGR of sessile oak (ERT)	6	1.0000
Height RGR of sessile oak (ET)	4	0.2482
Height RGR of sessile oak (ERT)	4	0.5050
Diameter RGR of European hornbeam (ET)	0	0.0209
Diameter RGR of European hornbeam (ERT)	5	0.7389
Height RGR of European hornbeam (ET)	7	0.7728
Height RGR of European hornbeam (ERT)	1	0.0956

RGR – relative growth rate, ET – effect of thinning, ERT – effect of reduced throughfall

Table 3: Mean values of diameter and height increments and RGR of sessile oak and European hornbeam

Tabelle 3: Mittlere Werte von Durchmesser- und Höhenzuwachs und den relativen Zuwachsraten der Traubeneiche und Hainbuche

Species	Growth reaction	Thinning		No thinning	
		Reduced throughfall*	Normal throughfall	Reduced throughfall*	Normal throughfall
sessile oak	diameter increment (mm year^{-1})	6.5	7.4 (1.55)	3.8	6.4 (2.30)
	diameter RGR (%)	19.8	19.7 (3.09)	12.7	13.2 (2.41)
	height increment (cm year^{-1})	56.3	63.0 (13.63)	57.3	47.1 (8.97)
	height RGR (%)	18.1	17.4 (3.23)	18.5	12.4 (2.86)
European hornbeam	diameter increment (mm year^{-1})	4.1	7.0 (0.28)	3.7	3.8 (0.08)
	diameter RGR (%)	19.3	21.0 (1.41)	12.7	10.9 (0.34)
	height increment (cm year^{-1})	64.0	75.6 (4.33)	90.9	86.7 (10.22)
	height RGR (%)	21.2	19.0 (1.46)	25.9	19.8 (2.98)

RGR – relative growth rate, values in parentheses represent standard error, * – standard errors are not calculated due to presence of only one thinned plot with reduced throughfall and one unthinned plot with reduced throughfall

Table 4: Comparison of diameter and height RGR between species

Tabelle 4: Vergleich von den relativen Durchmesser- und Höhenzuwachsraten von beiden Holzarten

	U value	p value
Diameter RGR SO x EH (thinned)	7	0.7728
Diameter RGR SO x EH (unthinned)	5	0.3865
Height RGR SO x EH	15	0.0742

RGR – relative growth rate, SO – sessile oak, EH – European hornbeam

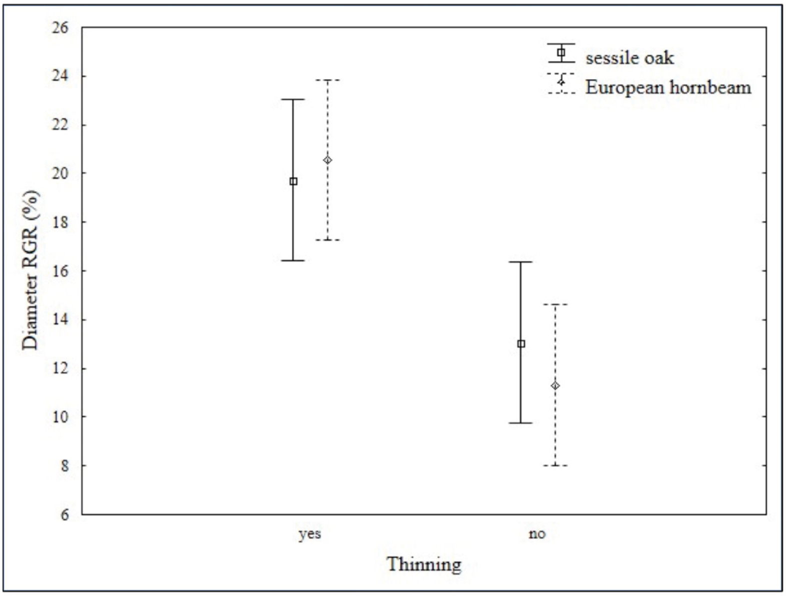

Figure 2: Comparison of mean values of diameter RGR (with 95% confidence intervals) between sessile oak and European hornbeam for thinned and unthinned plots

Abbildung 2: Vergleich von Mittelwerten von den relativen Durchmesserzuwachsraten (mit 95% Konfidenzintervallen) zwischen der Traubeneiche und der Hainbuche für durchforstete und undurchforstete Flächen

3.2 Height increment

The height RGR of sessile oak and European hornbeam were not significantly influenced by thinning and throughfall reduction (Table 2).

For the species comparison, only the effect of species was tested. The effect of thinning and the effect of throughfall reduction on species were not analysed due to their insignificance in Mann Whitney U tests. There were no statistical differences between the height RGR of sessile oak and European hornbeam (Table 4, Figure 3). Mean value of height RGR for sessile oak was 15.7%, and that value for European hornbeam was 20.4% (Figure 3).

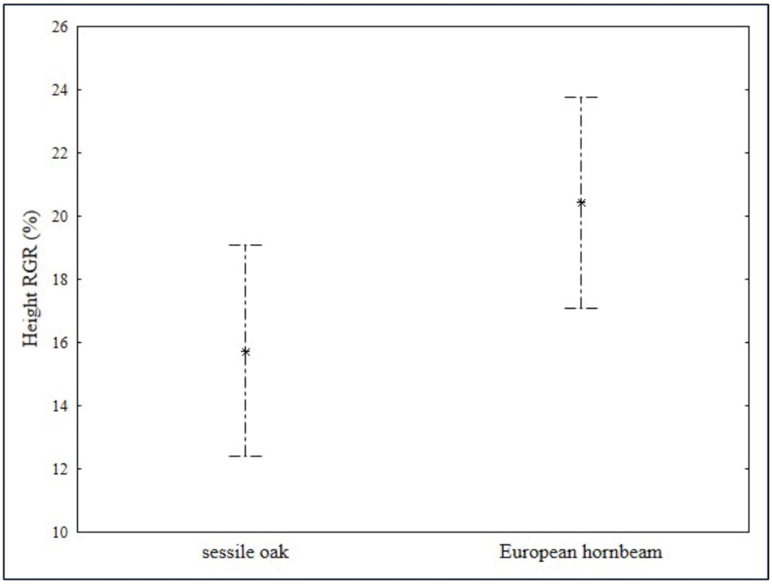

Figure 3: Comparison of mean values of height RGR (with 95% confidence intervals) between sessile oak and European hornbeam

Abbildung 3: Vergleich der Mittelwerte der relativen Höhenzuwachsraten (mit 95% Konfidenzintervallen) zwischen Traubeneiche und Hainbuche

3.3 Soil moisture

Due to small number of research plots we carried out ANCOVA for thinning and reduced throughfall separately. We used AWC_{red} as a covariate in both cases. The results of ANCOVAs showed that AWC_{red} was not statistically significant. AWC_{red} had no effect to soil moisture and could be removed from the analyses. To test the influence of thinning and reduced throughfall itself Mann Whitney U tests were used. Their results showed that soil moisture is significantly influenced by thinning, but is not influenced by reduced throughfall (Table 5). Soil moisture was significantly different in plots with thinning and without thinning (Figure 4).

Table 5: Effects of thinning and reduced throughfall on soil moisture

Tabelle 5: Einfluss der Durchforstung und des reduzierten Niederschlags auf die Bodenfeuchte

	U value	p value
Soil moisture (ET)	0	0.0209
Soil moisture (ERT)	6	1.0000

ET – effect of thinning, ERT – effect of reduced throughfall

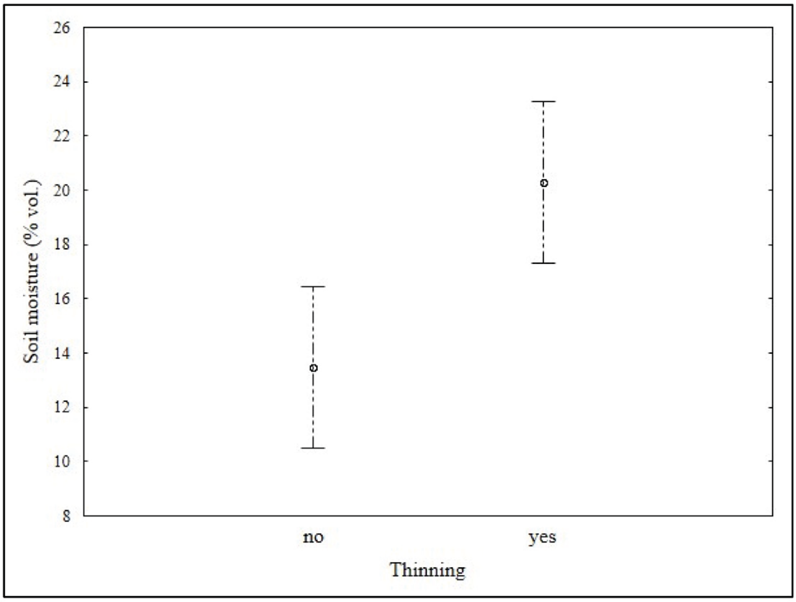

Figure 4: Comparison of mean values of soil moisture (with 95% confidence intervals) between thinned and unthinned plots

Abbildung 4: Vergleich der Mittelwerte der Bodenfeuchte (mit 95% Konfidenzintervallen) zwischen durchforsteten und undurchforsteten Flächen

4. Discussion

4.1 The effect of thinning on diameter increment, height increment and soil moisture of coppice

In our experiment, the diameter RGR of sessile oak in thinned plots with reduced throughfall was 56% higher than in unthinned plots and 49% higher in thinned plots with normal throughfall than in unthinned plots (Table 3). The diameter RGR of European hornbeam was 52% higher in thinned plots with reduced throughfall than in unthinned plots and 93% higher in thinned plots with normal throughfall. In addition, Cotillas et al. (2009) confirmed a positive effect of selective thinning on tree growth (by ca. 50%) in stands with both natural and reduced rainfall conditions. Nevertheless, the positive effects of thinning rapidly declined during their three-year experiment, probably because of the vigorous resprouting of thinned stumps.

The positive response of diameter increments to thinning reported in our experiment corresponds to findings of other authors (Lamson 1988; Ducrey, Toth 1992; Mayor, Rodà 1993; Cañellas et al. 2004; Cotillas et al. 2009). As stated in Cañellas et al. (2004), this could be explained by increases in the availability of resources (namely, water) for retained trees after the competition has been reduced.

In our experiment, the height increments of sessile oak and European hornbeam were not influenced by thinning, which resonates with other studies (Ducrey, Toth 1992; Amorini et al. 1998; Cañellas et al. 1998, 2004; Ciancio et al. 2006) and can be explained by the fact that height growth is less affected by the degree of crowding (Oliver, Larson 1996). Moreover, in species with weak epinastic control (e.g., oak), the height increment can be slowed down after a very strong release (Hamilton, Christie 1974). In Ducrey, Toth (1992), thinning in young coppice had little or no positive effect on height growth in comparison with older coppice stands. Therefore, the insignificant height RGR response to thinning in our experiment may be related to the young age of the coppice. In contrast, Lamson (1988) and Ciancio et al. (2006) found a positive effect of thinning on coppice growth.

We found that thinning had a statistically significant positive effect on soil moisture (Table 5, Figure 4). As Cotillas et al. (2009) confirmed, thinning in coppice could be an effective tool to increase soil moisture. According to Aragão (2012), thinning could be considered an inhibitor of the "biological water pump". Moreover, thinning increases soil moisture and the water table, and hence, it enhances the water availability for remaining individuals. However, this can be expected only in cases where there is sufficient available water in the soil, which strongly depends on soil composition and related properties, such as soil texture and aggregation, soil solution chemical status, osmotic pressure, organic matter content, and porosity (Gupta, Larson 1979; Hudson 1994; Huntington 2007).

4.2 The effect of reduced throughfall on diameter and height increments of coppice

In our experiment, reduced throughfall did not affected the diameter and height RGR of sessile oak and European hornbeam respectively (Table 2) The mean values of diameter and height RGR are very similar between plots with reduced throughfall and with normal throughfall for both studied species (Table 3). Additionally, sessile oak and European hornbeam mean diameter RGR and mean height RGR values did not differ significantly (Table 4, Figure 2, 3).

Green olive tree (*Phillyrea latifolia* L.) showed an indifferent relationship to reduced throughfall even 5 years following intervention (Ogaya, Peñuelas 2006). Similar results were obtained by Barbeta et al. (2013) in the same area of Spain. In contrast, the negative effect of reduced throughfall on radial growth of *Q. ilex* and strawberry tree (*Arbutus unedo* L.) was reported in Ogaya et al. (2003).

In Cotillas et al. (2009), 20% decrease in the height RGR in *Q. cerrioides* was observed due to a three-year reduction in throughfall in northeastern Spain. *Q. ilex* height RGR values in the same experiment were not reduced, and the differences between plots with and without reduced throughfall were not statistically significant. The age of coppices evaluated in Spain and that in our experiment were comparable. The Spanish coppice was established after a fire (Espelta et al. 2003), while the Czech coppice was established after a clear-cut (Kadavý et al. 2011).

The results in Rodríguez-Calcerrada et al. (2011) did not suggest any effect of a 6-year throughfall reduction on the diameter increment of *Q. ilex* in southern France.

Long-term experiments aimed at studying the consequences of throughfall reduction imply a significant reduction in growth and higher mortality in different ecosystems (Hanson et al. 2001; da Costa et al. 2010; Wu et al. 2011). However, as reported by Wagner et al. (2012), there may be exceptions. For example, reduced growth has not been demonstrated (indifferent effect) in *Quercus* species in the southeastern region of the USA. Additionally, no effects on growth of *Q. ilex* due to throughfall reduction were observed in southern France (Rodríguez-Calcerrada et al. 2011). The results of our study, unlike other studies, did not confirm a decline in growth after throughfall reduction. As stated before, the influence of throughfall reduction on the diameter RGR and the height RGR of both studied species could not be confirmed. The 30% throughfall reduction may have been insufficient for the conditions of our experimental plot (i.e., oak and hornbeam coppice in Central Europe). However, research describing this relationship in this field has been lacking thus far.

5. Conclusions

The objective of this paper was to study the effects of thinning and reduced throughfall on the growth and soil moisture of oak-hornbeam coppice. Our results showed that the effect of thinning on diameter RGR was statistically significant for both of the studied species. However, reduced throughfall had no statistically significant effect on the diameter RGR of sessile oak and European hornbeam. The height RGRs of sessile oak and European hornbeam were not influenced by thinning and reduced throughfall. Only thinning had statistically significant effect on soil moisture. Reduced throughfall and available water capacity reduced by stoniness percentage and thickness of soil genetic horizon (AWC_{red}) had no effects on soil moisture.

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