Soil preparation by ploughing in the floodplain forest and its influence on vegetation and primary soil characteristics

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ABSTRACT: The paper analyzes the effect of whole-area site preparation by ploughing and of alternate field and forest crops on the understorey, soil biological activity and physical and chemical characteristics in the commercial forest. Another factor of the study was to assess the effect of the clearcut size on forest stands. Analyzed were 20-years-old stands of pedunculate oak (*Quercus robur* [L.]) on alluvial sites 1L9 (*Fraxino pannonicae-Ulmetum*). It can be deduced from the conducted analyses that after twenty years neither different site preparation nor clearcut size affected the understorey and soil biological activity. Field crops and forestry in alternation had a significantly adverse effect on porosity and water-retention capacity in the lower layer of top-soil (25–30 cm). Whole-area ploughing had a negative influence on the loss of organic substances due to accelerated mineralization. Nevertheless, the observed differences are not significant; the values did not fall below critical limits and in no case did they affect other studied site parameters or the development of root systems and aboveground parts of oak trees.

Keywords: floodplain forests; mechanical site preparation by ploughing; physical and chemical soil analyses; phytocoenology; soil biological activity

The elimination of an adverse influence of weeds is one of the crucial problems in the regeneration of forests in floodplain ecosystems. During the growing season, weeds can grow up to a height of 150 cm even if the access of solar radiation is very low. They can considerably suppress the crops of target species and even make their regeneration impossible in some cases. Weeds remove water and nutrients, and in the pedunculate oak, which is an expressively light-loving species, they reduce the penetration of light whose shortage may result in the very rapid death of young trees (Lüpke 1998; Houšková 2004; Kühne, Bartsch 2005). Vyskot (1958) already pointed out that the undergrowth and the grass-herb layer often hampered regeneration in floodplain forests and that the shrub layer ought to be cut out and the soil loosened. Nilsson et al. (1996) extended upon this finding with their idea of weed destruction by means of soil preparation. The choice of regeneration technology is also affected by other factors, such as poor emergence rate of pedunculate oak seedlings (Matić 1996) which is often stimulated by soil preparation. Natural regeneration would be the best way to regenerate the pedunculate oak. However, the long-term insufficient fructification of this species (Kotrla 1999, 2000; Vacek et al. 2000) stands behind the fact that artificial regeneration has been prevailing, namely regeneration by planting. Opinions are presented without evidence that regeneration by planting adversely affects the root system development

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in the pedunculate oak, which is – along with the mechanical site preparation – also the reason for the species decline in the region. In southern Moravia, whole-area deep ploughing (to a depth of 40 cm) has been applied for many tens of years as well as agroforestry (simultaneous growing of forest and field crops at one place and at the same time). Forest practices have not revealed any differences in the growth response of pedunculate oaks regenerated on plots after the whole-area soil preparation by ploughing (agroforestry) and on plots without the mechanical soil preparation. In exact analyses, Mauer et al. (2007) did not find any significant variances in the growth of the aboveground part or root system of this most widespread tree species. Gemmel et al. (1996) also found out that the soil preparation did not affect the growth of pedunculate oak transplants. There arises a question if these interventions into the forest ecosystem cannot affect other ecotope characteristics.

The goal of the present study was to compare the understorey, soil biological activity, and chemical and physical soil characteristics in 20-years-old stands of pedunculate oak in the commercial forest. The stands are of identical age and site and differ in the size of regenerated clearcuts and in the method of site preparation before reforestation.

MATERIAL AND METHODS

Basic methodological procedures

The tests included 20-years-old stands of pedunculate oak (*Quercus robur* [L.]) on sites 1L9 (*Fraxino pannonicae-Ulmetum*). All stands were of identical density (1.0), at an altitude of 160 m a.s.l. in floodplain forests managed by the Forest Enterprise of Forests of the Czech Republic (LČR) in Židlochovice (48°45' N and 17°1' E). The stands differed in the method of site preparation before regeneration – whole-area ploughing, agroforestry, no soil preparation, and in the clearcut size at regeneration – up to 3.00 ha (small clearcuts) and above 3.50 ha (large clearcuts). Detailed characteristics of analyzed stands are presented in Table 1. The survey included 6 variants. Individual variants are expressed as three-figure codes for a better orientation in the table of results. The first figure (letter) is for soil preparation before regeneration: B = no site preparation, O = hole-area ploughing, P = agroforestry. The second figure (letter) is for clearcut size: M = small clearcut, V = large clearcut. The third figure (numeral) denotes a concrete stand because some analyses included pairs of identical forest stands. The number of stands analyzed in the tests was not identical. However, the basic aspect of analyzing the different methods of site preparation and the different sizes of clearcuts was respected at all times. The term agroforestry is taken to mean that after oak planting (sowing), agricultural crops were grown in the inter-rows. The used agricultural crops were only root crops, most frequently potatoes, beet, maize, exceptionally sunflower. The alternate system of forest and farm crops was in use for a maximum time of three years. Pursuant to prearranged procedures, the regenerating oak was treated along with the cultivation of farm crops.

Understorey

Forest type determination required a detailed study of typological maps from 1964 to 1999. The

Table 1. Characteristics of the analyzed forest stands

Stand	Stand No.	Site preparation	Forest type	Altitude (m a.s.l.)	Clearcut size (ha)	Stand age (years)	Stand density
BM1	922F2a	none	1L9	160	3.00	22	1.00
BM2	928A2	none	1L9	160	1.86	18	1.00
BV1	914B2	none	1L9	160	3.72	18	1.00
BV2	933B2	none	1L9	160	4.25	17	1.00
OM1	922C2	whole-area ploughing	1L9	160	0.90	21	1.00
OM2	930B2	whole-area ploughing	1L9	160	1.89	20	1.00
OV1	914A2	whole-area ploughing	1L9	160	4.32	19	1.00
OV2	919C2	whole-area ploughing	1L9	160	6.30	18	1.00
PM1	926D2a	agroforestry	1L9	160	2.07	19	1.00
PV1	913B2	agroforestry	1L9	160	6.27	18	1.00
PV2	931D2	agroforestry	1L9	160	4.54	18	1.00

concerned forest type (1L9 – *Fraxino pannonicae-Ulmetum*) was precisely localized in each forest stand and its development in the course of years was determined. A field survey of the stand was conducted and transects 20 × 20 m were demarcated on which phytocoenological relevés were taken. Subject of research was the vernal aspect (27 April–2 May 2007) and the aestival aspect (24–27 August 2007). The survey included all variants in a double replication.

The phytocoenological relevés were processed using TURBOVEG for Windows Version 2.57 (Hennekens, Schaminee 2001). Values presented in the tables of results are those of the combined scale of abundance and dominance.

Plant communities were characterized by the ecologico-coenotic classification of Ellenberg indicator values (Ellenberg et al. 1992). Results were processed using JUICE Version 6.4 (Tichý 2002). In the evaluation, pairs of identical stands were consolidated (site preparation, clearcut size).

Soil biological activity

One forest stand was chosen from each variant (BM2, BV1, OM1, OV2, PM1 and PV2). Soil was sampled on 20 June 2007 at three places in each stand and a composite sample was prepared for the analyses. The soil samples were taken from mineral horizons of 5–10 cm under the soil surface.

The analyses were carried out according to methodological procedures developed by Foukalová and Pokorný (2006) using a Vaisala instrument, Model GMT 220.

The values of soil biological activity obtained from the analyses were as follows:
- basal respiration (B),
- respiration after addition of ammonia nitrogen (ammonium sulphate) (N),
- respiration after addition of glucose (G).

The coefficients obtained from these values by calculation (ratio) were as follows:
- physiological availability of soil nitrogen (in tables denoted as N:B),
- amount of readily available soil organic substances (in tables denoted as G:B),
- ratio of available soil carbon/nitrogen (in tables denoted as G:N),
- factor of complex effect (in tables denoted as FKP).

N:B shows the physiological availability of soil nitrogen. The higher the N:B value, the lower the physiological availability of soil nitrogen. If the soil contains a sufficient amount of available nitrogen, the respiration will not increase upon a further nitrogen addition and the N:B value will be near to 1.

G:B indicates the amount of readily available organic substances in the soil. Similarly like in the above coefficient, higher values of G:B point to a lower amount of available organic substances in the soil.

G:N gives a picture about the mutual ratio of carbon and nitrogen in the soil. Regarding the fact that carbon is always used at higher amounts than nitrogen, the G:N ratio is equal approximately to 5 at a balanced physiological ratio of the two elements. At lower values of this coefficient soil microorganisms from the soil sample are relatively better nourished with organic substances than with nitrogen while at higher values the situation is reversed.

Four of the above values (B, N, G, NG) can be used to calculate the exposure complex factor (FKP) – the deviation from 1 says that the extent factors, especially physical factors, allow fuller utilization of carbon and nitrogen in the complex than it was the product of such action in a separate application (Novák, Apfelthaler 1964).

Soil physical and chemical characteristics

Due to laboriousness, the analyses were carried out only in variants BM2, OV1 and PV1 (on sites where Mauer et al. [2007] simultaneously surveyed the development of aboveground parts and root system in the pedunculate oak).

Soil pits were excavated by hand down to the groundwater table in all analyzed stands.

Representativeness of the soil pits was established according to bioindicative traits and benchmark dug-outs. Soil samples for the analysis of chemical and physical properties of soils were taken according to standard procedures (Zbíral 2002) from all diagnostic horizons excluding forest floor horizons (Zbíral 2002).

Soil texture was established using the pipette method according to Zbíral (2004). Laboratory works in the accredited laboratory of the company Ekola Bruzovice, s. r. o. (CR) included analyses of active (pH/H_2O) and potential (pH/KCl) soil reaction with a pH-meter with a combined glass electrode (soil/H_2O or 1M KCl =1:2.5)**,** of H^+ concentration based on the principle of double pH measurement and of available mineral nutrients (Ca, Mg, K) from the Mehlich II extract by the method of atomic adsorption spectrophotometry (Mehlich 1978). The content of phosphorus was determined by a spectrophotometric method in the solution of ascorbic acid, H_2SO_4 and Sb^{3+}. Carbon contained in humus acids (hereinafter C-HS) was determined by a spectrophotometric

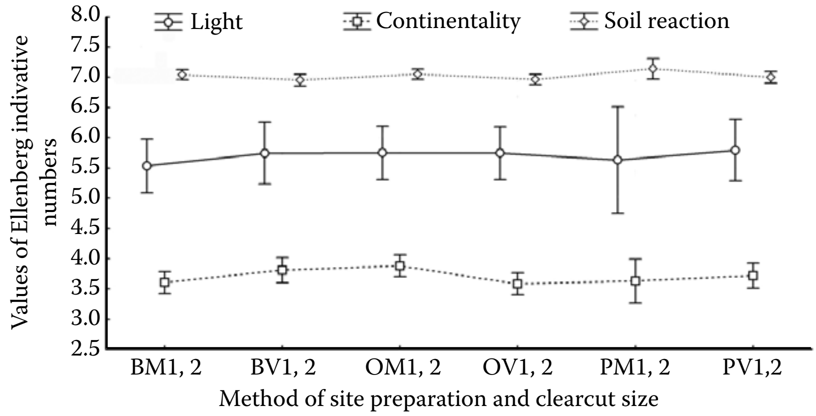

Fig. 1. Undergrowth requirements for light, continentality and soil reaction

method according to characteristic adsorbances in pyrophosphate. Carbon contained in humic acids (hereinafter C-HA) and carbon contained in fulvic acids (hereinafter C-FA) were detected. These data served to express the value of the C-HA/C-FA ratio (Vavříček 2006). Oxidizable organic carbon (C_{ox}) was established by endothermic extraction in the chromium-sulphur mixture. The gas mixture was in surplus and the untreated residue was ascertained through the "dead stop" titration with ammonium ferrous sulphate. Total nitrogen content (N_t) was established by Kjeldahl's method (Zbíral et al. 1997).

– Statistical evaluation of the physical soil properties was done by means of one-factor ANOVA and multiple comparison by Scheffé's test at a significance level α = 0.05.

RESULTS AND DISCUSSION

Effect of the whole-area site preparation by ploughing on the synusia

It follows from Table 2 that *Galium aparine* (L.) and *Ficaria bulbifera* Holub. were dominant undergrowth species in the vernal aspect on all studied plots, which according to Chytrý et al. (2001) are typically occurring in the hardwood forests of lowland rivers – i.e. IL sites. The neophyte species *Aster lanceolatus* Willd. dominated in most stands after ploughing and alternate forest and field crops. On sites without site preparation, *Aster lanceolatus* Willd. occurred to a lesser extent and dominated only in one stand with no soil preparation (BM2). The other above-mentioned species were not fixed as dominants to either site preparation or clearcut size but rather correlated with an imaginary hydric series.

*Urtica dioica (*L.) and *Rubus caesius* (L.) were other species abundant in the undergrowth of vernal aspect, which never dominated but whose coverage often reached 10-20%. Regarding the density of the main layer, shrub layer species exhibited only a very low coverage and in some stands they were even nearly missing. *Acer campestre* (L.), *Cornus sanguinea* (L.) and *Crataegus* sp. were the species frequently occurring in this layer. The tree layer was dominated by a sole species – *Quercus robur (*L.), whose coverage was above 90%. With the exception of *Aster lanceolatus* Willd., all above-mentioned

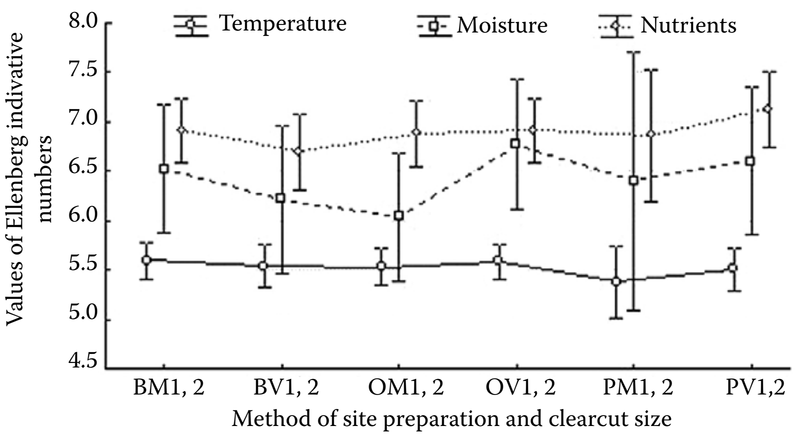

Fig. 2. Undergrowth requirements for temperature, moisture and nutrients

Table 2. Phytocoenological relevés of the forest stands – (vernal aspect; altitute 160 m a.s.l.; exposure and gradient were not included)

Stand		BM1	BM2	BV1	BV2	OM1	OM2	OV1	OV2	PM1	PV1	PV2
Total cover		95	100	90	100	95	100	90	100	90	85	100
Species name												
Tree	*Quercus robur* (L.)	+5	+5	+5	+5	+5	+5	+5	+5	+5	+5	+5
Shrub	*Acer campestre* (L.)	+		+	+	+	1					
	Acer pseudoplatanus (L.)											
	Cornus sanguinea (L.)		+	1	+	1				–		+
	Crataegus sp.	–	+		+				+	+	1	
	Fraxinus angustifolia Vahl.	+			1	–	–		–	+		–
	Prunus spinosa (L.)	+		+	1			1	–			
	Quercus robur (L.)									1		
	Sambucus nigra (L.)					1						
Herb	*Aegopodium podagraria* (L.)										+	
	Aster lanceolatus Willd.	+	–3		+	1	–2	+2	+3	+3	+2	+3
	Brachypodium sylvaticum Huds.	1	+	1			+					
	Carex riparia Curtis.	1			–2		–2	1	+		+2	
	Crataegus sp.			+								
	Deschampsia cespitosa (L.) Beauv.	+		+	+							
	Ficaria bulbifera Holub.	–3	–2	+3	+2	–2	+3		+2		1	+2
	Fraxinus angustifolia Vahl.	+		–			+		–	+		
	Galium aparine (L.)	–2	+2	–2	+3	–3	+2	–3	+2		+	+2
	Geum urbanum (L.)			+		1	+				+	
	Glechoma hederacea (L.)	+	+	–2	1	+	1			1	+	
	Impatiens parviflora D.C.	1			+							
	Iris pseudacorus (L.)	–	–		1				–	–	+	–
	Lamium maculatum (L.)										–	
	Lysimanchia nummularia (L.)									1		
	Rubus caesius (L.)	+2	+	–	+2	1	1	–3	1	+2	+2	–2
	Rumex sanguineus (L.)	–	+	–				+	–			
	Stachys sylvatica (L.)	+						+	–			
	Symphytum officinale (L.)	–	–									
	Urtica dioica (L.)	1	–2	+2	1	–3	–2	1	+	+2	–2	

species of the vernal aspect are typical of hardwood floodplains, i.e. 1L sites (Chytrý et al. 2001).

As compared with the vernal aspect, the aestival aspect had a lower abundance of species (Table 3). *Aster lanceolatus* Willd. dominated on all sites after the soil preparation and on one site without soil preparation. *Ficaria bulbifera* Holub. as a terrestrial species dominating in the vernal aspect and the omnipresent *Galium aparine* (L.) were absent in the aestival aspect and replaced by the dominant *Rubus caesius* (L.) and *Urtica dioica* (L.) In one case, a site with no soil preparation was dominated by the very low-rise species of *Glechoma hederacea* (L.) *Carex riparia* Curtis was another species preferring increased soil moisture while it occurred more frequently in the aestival aspect. Other species were represented by a few individuals only.

Undergrowth requirements for light, continentality and soil reaction are presented in Fig. 1. Vertical columns leading from the points that represent the respective means denote 95% confidence limits. The figure shows that the herbs in the undergrowth had very similar requirements for the soil reaction. There is no significant statistical difference between the understoreys in the individual stands although the confidence intervals are very small. Therefore, it can be concluded that the herbs in all stands prefer relatively high pH given by the eubasic soil variety. Light requirements of the undergrowth ranged within standard values. Mean values were equable again in all stands – confidence limits coincided. It further follows from Fig. 1 that the herbs in the undergrowth are not exacting in terms of climatic conditions related to the geographical position amidst extensive continents. Mean Ellenberg indices of continentality exhibited no statistically significant difference.

Fig. 2 illustrates the undergrowth requirements for temperature, moisture and nutrients. With respect to the fact that the survey was conducted in floodplain forests, the demand for nutrients was logically very high in all herb species with the arithmetic means of Ellenberg indices ranging about 7 but showing no significant difference. The undergrowth synusia needs high soil moisture. The mean values of indices which represent temperature did not exhibit any statistically significant differences.

The effect of whole-area site preparation by ploughing and of agroforestry on the soil biological activity

Table 4 documents that the basal respiration of soil samples varied. Statistical significance by means of multiple comparisons with the use of Scheffé's test at a significance level $\alpha = 0.05$ disclosed that stands OM1 and PV2 are mutually indifferent. The highest activity of the soil edaphon was observed in stand BM2 (2.20 μg $CO_2 – C{\cdot}g^{-1}dw{\cdot}h^{-1}$) while the lowest value of basal respiration was found in stand BV1 (1.76 μg $CO_2 – C{\cdot}g^{-1}dw{\cdot}h^{-1}$). But our results have a different informative value as compared with the literary data. Růžek et al. (2006) determined the mean value of basal respiration for Fluvisols to be 1.23 μg $CO_2 – C{\cdot}g^{-1}dw{\cdot}h^{-1}$. Novák (1969) reported the basal respiration values from 1.64 μg to 3.71 μg $CO_2 – C{\cdot}g^{-1}dw{\cdot}h^{-1}$ in layers from 3 to 13 cm, Šantrůčková (1993) measured the values from 0.30 μg to 3.36 μg $CO_2 – C{\cdot}g^{-1}dw{\cdot}h^{-1}$. On Fluvisols in the Elbe River floodplain forests, Rinklebe and Langer (2006) measured even the basal respiration of 4.73 μg $CO_2 – C{\cdot}g^{-1}dw{\cdot}h^{-1}$.

Looking at the N:B coefficients, we can say that the physiological availability of soil nitrogen is high and equable in all stands (mostly around 1). Lhotský (1987) reported the coefficient values from 1.19 to 1.34 on forest soils in year 7 after ploughing, which indicates that the forest stands studied by us have a very good physiological availability of soil nitrogen and that the values measured by us are more equable in most cases than those published by Novák (1969) on Luvisols.

As compared with literature, the amount of readily available organic substances (G:B) is high and relatively equable in all studied forest stands. Lhotský (1987) reported a range from 4.50 to 7.69 on forest soils seven years after ploughing, Foukalová and Pokorný (2006) determined a range of values from 3.72 to 16.32 in the layer up to 15 cm.

Calculated values of the G:N coefficient indicate that the soil microorganisms in forest stands monitored by us are better supplied with organic substances than with nitrogen and the values are very equable with the exception of stand OV2. Foukalová and Pokorný (2006) measured the range of G:N values from 2.32 to 7.93.

The factor of complex effect (FKP) ranges in the stands from 1.22 to 2.16, the values pointing to a lower utilization of carbon and nitrogen in the complex effect than it would correspond to the product of this effect in the case of separate application. Nevertheless, the values are similar in all stands as compared with the literature, i.e. ranging from 1.74 to 10.43 (Foukalová, Pokorný 2006).

We can conclude that in spite of some partial variances, whole-area ploughing, agroforestry or different clearcut size have no influence on the biological activity of soil.

Table 3. Phytocoenological relevés of the forest stands – aestival aspect (aestival aspect; 160 m a.s.l.; exposure and gradient were not included)

Stand		BM1	BM2	BV1	BV2	OM1	OM2	OV1	OV2	PM1	PV1	PV2
Total cover		95	100	85	100	95	100	100	100	90	100	100
Species name												
Tree	*Quercus robur* (L.)	+5	+5	+5	+5	+5	+5	+5	+5	+5	+5	+5
Shrub	*Acer campestre* (*L.)*	+		+	+	+	1					
	Acer pseudoplatanus (L.)											
	Cornus sanguinea (L.)		+	1	+	1				–		+
	Crataegus sp.	–	+		+				+	+	1	
	Fraxinus angustifolia Vahl.	+			1	–	–		–	+		–
	Prunus spinosa (L.)	+		+	1			1	–			
	Quercus robur (L.)									1		
	Sambucus nigra (L.)					1						
Herb	*Aegopodium podagraria* (L.)										+	
	Aster lanceolatus Willd.	1	+3	–	1	+2	+2	+4	+4	+3	–3	+4
	Brachypodium sylvaticum Huds.	1	+	1			+					
	Carex riparia Curtis.	1			–2	–2	–2	+	+		+2	
	Crataegus sp.			+								
	Deschampsia cespitosa (L.) Beauv.	1		+	+							
	Ficaria bulbifera Holub.											
	Fraxinus angustifolia Vahl.	+		–			+		–	+		
	Galium aparine (L.)											
	Geum urbanum (L.)	1		+			+				+	
	Glechoma hederacea (L.)	1	1	+3	1	–2	1			+	+	
	Impatiens parviflora D.C.											
	Iris pseudacorus (L.)	–	–		1				–	–	+	–
	Lamium maculatum (L.)											
	Lysimanchia nummularia (L.)									1		
	Rubus caesius (L.)	–3	–2	–	–3	+2	1	–2	–2	+2	+2	–2
	Rumex sanguineus (L.)		+									
	Stachys sylvatica (L.)								–			
	Symphytum officinale (L.)	–	–									
	Urtica dioica (L.)	–3	+2	+2	+2	1	+2	1	+	–2	1	

Table 4. Values of basal and relative respiration

Stand	B	N:B	G:B	G:N	FKP
	($\mu g\ CO^2 - C \cdot g^{-1} dw \cdot h^{-1}$)				
BM2	2.20	0.894	2.276	2.546	1.740
BV1	1.76	1.040	2.551	2.454	1.648
OM1	2.01	1.027	2.300	2.239	1.460
OV2	1.94	0.711	3.036	4.268	2.161
PM1	1.82	0.863	1.977	2.291	1.397
PV2	2.00	1.019	2.286	2.243	1.236

The effect of whole-area site preparation by ploughing and of agroforestry on physical and chemical soil characteristics

The fundamental presumption that 1L9 forest types (*Fraxino pannonicae-Ulmetum*) will exhibit the identical soil subtype was not demonstrated. Our forest stands (BM2, OV1, PV1) have different soil subtypes. Site with no soil preparation (BM2) – gleyic eubasic Fluvisol, soil horizons: 0–1.5 cm – horizon L, 1.5–3 cm horizon F, 3–8 cm horizon Ah, 8–25 cm horizon Ahm, 25–52 cm horizon Mg_1, 52–85 cm horizon Mg_2. Site with whole-area ploughing (OV1) – gleyic eubasic Fluvisol, soil horizons: 0–3 cm horizon L+F, 3–17 cm horizon Ahp, 17 to 38 cm horizon Ap, 38–68 cm horizon Mg_1, 68–98 cm horizon Mg_2, 98–128 cm horizon Mg_3. Site with alternate field and forest crops (PV1) – gleyic eubasic Fluvisol, soil horizons: 0–2 cm horizon L+F, 2–11 cm horizon Ahp, 11–29 cm horizon Apg, 29–43 cm horizon Mg_1, 43–72 cm horizon Mg_2, 72–110 cm horizon Mg_3. Primary differences consist in the fact that the local site characteristics determine the development of gleyic soil subtypes up to the gleyic subtype of Fluvisol (induced by the vicinity of a secondary watercourse). Another important variance is in the stand with no site preparation (BM2), which exhibits deep salinization (Cl^- and SO_4^{2-}) in the form of finely crystalline fractions in lower layers from a depth of 40 cm, significantly from 60 cm (salinization not being induced by anthropogenic measures).

Particle density does not fluctuate very much, ranging within the standard values of mineral soils (2.5–2.7 $g \cdot cm^{-3}$), which indicates that it is neither significantly affected by C-substances, particularly by their fermentation and humification fractions. This is also confirmed by the high intensity of mineralization – defined for example by the C:N ratio, which is very low in all soil pits, ranging between 8–11:1 even within the respective soil horizons.

Reduced bulk density of soil is one of the criteria used to classify the soil environment quality, namely in respect of aerobic and respiring edaphon. The upper optimal limit (1.6 $g \cdot cm^{-3}$) was exceeded in partial horizons only sporadically. The relatively worst situation was observed on the site with a single whole-area ploughing treatment (OV1) where it reached on average 1.7 $g \cdot cm^{-3}$ from a depth of ca 70 cm, however the reason not being the whole-area soil preparation but the effect of the site and soil-forming processes.

Table 5 shows that soil porosity does not fall below the critical level of 35% in any horizon on the surveyed plots. As compared with the intact profile, the topmost soil horizons of surveyed plots showed a diverse and in general significantly adverse effect of both whole-area treatments. No such difference was recorded between the used technologies in the organomineral horizon. Agroforestry appears to be a greater threat to the porosity of the shallow subsoil (25–35 cm) in which porosity showed a statistically significant decrease. Thus, in the plot with agroforestry, which is also under a greater hydric influence, the porosity values of about 42% become slightly below the lower optimal limit (45%). Such sites already belong to the group of compacted soils. In the technologies of whole-area soil preparation, the lower horizons may show the risky values of very compacted soils (P – 35%). The trend was not observed in the soil profiles of sites without soil preparation; however, the differential may result from the specific edatope of this locality.

High water sorption and soil swelling capacity on the control plot with no treatment – the plot of the intact profile showed significantly in the evaluation of a very important variable – minimum air capacity. The values of deep horizons from about 40 cm were close to zero. No such problem existed in the other plots.

Table 5. Physical parameters of the soil – units in volume percentage

Stand	Depth (cm)	Actual moisture (%)	Field moisture capacity (%)	Maximum water capacity (%)	Water retention capacity (%)	Reduced bulk density($g \cdot cm^{-3}$)	Particle density ($g \cdot cm^{-3}$)	Porosity (%)	Minimum aircapacity (%)
BM2	10-15	38.89 ± 0.15	41.42 ± 1.11	39.21 ± 0.99	33.18 ± 0.80	**1.24 ± 0.05**	2.64 ± 0.06	**52.94 ± 1.28**	13.73 ± 1.55
	25-30	39.32 ± 1.17	**53.08 ± 2.10**	**48.39 ± 2.01**	**38.41 ± 1.31**	1.40 ± 0.03	**2.73 ± 0.01**	48.60 ± 0.89	**0.22 ± 2.76**
	50-58	**36.73 ± 1.32**	**53.33 ± 2.19**	**48.10 ± 2.17**	**38.20 ± 2.28**	1.53 ± 0.01	2.75 ± 0.01	**44.54 ± 0.05**	**0.15 ± 2.11**
	80-85	**37.10 ± 1.21**	**54.99 ± 2.43**	**48.94 ± 1.95**	**38.17 ± 1.50**	**1.54 ± 0.02**	2.68 ± 0.08	**42.61 ± 2.31**	**0.09 ± 1.31**
OV1	10-15	39.57 ± 2.61	41.03 ± 0.60	38.94 ± 0.51	32.03 ± 0.44	1.33 ± 0.03	2.61 ± 0.01	48.92 ± 1.24	9.98 ± 1.65
	25-30	39.50 ± 2.00	43.21 ± 0.75	40.19 ± 0.35	33.28 ± 0.17	1.38 ± 0.03	2.58 ± 0.05	46.68 ± 1.98	6.49 ± 2.33
	50-58	**31.66 ± 0.91**	39.48 ± 1.34	36.93 ± 1.19	29.21 ± 0.98	1.63 ± 0.03	**2.68 ± 0.01**	**39.12 ± 0.90**	2.24 ± 1.27
	80-85	27.92 ± 0.92	35.96 ± 0.74	33.22 ± 0.62	25.67 ± 0.53	1.71 ± 0.02	2.65 ± 0.01	**35.50 ± 1.18**	2.28 ± 1.33
PV1	10-15	37.20 ± 0.90	39.97 ± 0.59	37.76 ± 0.63	31.83 ± 0.56	**1.39 ± 0.03**	2.63 ± 0.03	47.07 ± 1.22	9.31 ± 1.78
	25-30	.32.49 ± 3.99	38.04 ± 4.12	35.41 ± 3.60	**28.06 ± 3.20**	**1.53 ± 0.03**	**2.67 ± 0.03**	42.72 ± 0.85	7.31 ± 2.74
	50-58	32.63 ± 1.91	38.19 ± 0.91	35.57 ± 1.25	28.26 ± 1.28	1.59 ± 0.02	2.74 ± 0.02	42.12 ± 2.51	6.56 ± 1.53
	80-85	30.44 ± 0.58	39.96 ± 1.08	35.78 ± 0.62	28.24 ± 0.55	1.67 ± 0.01	2.72 ± 0.01	38.60 ± 0.30	2.82 ± 0.36

Values in bold letters significantly differ from values in the same horizon

Table 6. Chemical parameters of the soil

Stand	Depth (cm)	pH (H_2O)	pH (KCl)	Oxalates (g•kg⁻¹) Fe	Oxalates Al	Chromium sulphate mixture (%) C	N	C:N	Sodium pyrophospate (%) C-HS	C-HA	C-FA	HA/FA	2M HNO3 (mg•kg⁻¹) Mn
BM2	10–15	6.50	5.24	9.80	1.64	3.45	0.42	8.21	1.53	0.76	0.79	0.96	611.00
	25–32	6.92	5.49	14.00	1.58	1.95	0.17	11.47	0.52	0.25	0.27	0.93	720.00
	50–58	7.00	5.78	12.50	1.57	0.96	0.12	8.00	0.34	0.15	0.19	0.79	825.00
	80–88	7.09	6.08	4.72	1.61	0.71	0.07	10.14	0.18	0.09	0.09	1.00	381.00
OV1	10–15	6.60	5.15	9.29	1.90	1.87	0.24	7.79	0.78	0.34	0.43	0.79	619.00
	25–32	6.70	5.09	9.52	1.95	1.60	0.21	7.62	0.69	0.29	0.41	0.71	681.00
	50–58	6.83	5.38	6.14	1.33	1.18	0.08	14.75	0.21	0.11	0.10	1.10	463.00
	80–88	6.95	5.55	5.22	1.01	0.59	0.06	9.83	0.16	0.10	0.07	1.43	307.00
PV1	10–15	6.18	4.95	7.95	1.82	3.30	0.29	11.38	0.88	0.44	0.43	1.02	449.00
	25–32	6.45	5.18	8.10	1.86	1.98	0.18	11.00	0.56	0.22	0.33	0.67	344.00
	50–58	6.64	5.35	4.79	1.41	0.74	0.08	9.25	0.22	0.09	0.13	0.69	387.00
	80–88	6.71	5.54	6.76	1.26	0.71	0.06	11.83	0.19	0.09	0.09	1.00	488.00

Stand	Depth (cm)	Water extract 1 : 5 (mS•cm⁻¹) conduct.	(mg•kg⁻¹) Cl–	S–SO4	Mehlich II (mg•kg⁻¹) P	Mg	Ca	K	Mehlich CEC – cumulative measurement (mmol.chem.eq.•kg⁻¹) H+	Mg	Ca	K	Al	sum CEC	Mg:K	v (%)
BM2	10–15	0.070	6.20	36.50	5	679	6.893	302	56	55.90	344.00	7.70	0.80	464.40	7.20	87.80
	25–32	0.088	30.90	57.30	<1	789	8.133	202	42	64.90	405.80	5.20	0.40	518.40	12.50	91.80
	50–58	0.229	63.00	61.30	<1	851	8.262	139	34	70.00	412.30	3.60	0.40	520.30	19.70	93.40
	80–88	0.572	80.30	90.40	<1	964	8.493	107	30	79.30	423.80	2.70	0.00	535.90	28.90	94.40
OV1	10–15	0.052	6.70	12.80	<1	696	6.490	212	42	57.30	323.90	5.40	1.60	430.20	10.50	89.90
	25–32	0.048	6.60	17.70	<1	692	7.362	164	47	57.00	367.40	4.20	1.20	476.70	13.50	89.90
	50–58	0.050	10.30	47.90	<1	592	5.083	102	30	48.70	253.60	2.60	2.80	337.80	18.60	90.30
	80–88	0.072	6.10	54.10	<1	501	4.041	90	27	41.20	201.60	2.30	1.20	273.40	17.90	89.70
PV1	10–15	0.050	11.40	28.60	6	668	6.180	215	56	55.00	308.40	5.50	4.40	429.30	10.00	85.90
	25–32	0.054	12.10	34.60	<1	652	6.723	151	42	53.70	335.50	3.90	0.80	435.80	13.90	90.20
	50–58	0.064	12.50	42.40	<1	599	5.433	105	31	49.30	271.10	2.70	1.20	355.30	18.30	90.90
	80–88	0.100	24.60	83.90	<1	606	5.590	96	28	49.90	278.90	2.50	0.80	360.10	20.30	92.00

Soil reaction on the researched plots was at the level of slightly acidic soils. Due to the action of sodium (Na) on the sorption complex in deep horizons of the intact plot (BM2) its value for the exchange soil reaction increased up to a level of neutral limits. In the case of these woody species it was rather an inhibition factor (Úradníček et al. 2009) (Table 6).

The best-quality decomposition with the highest production of humification fractions of active humus (1.53%) was recorded in the topmost layer of genetically intact horizons (BM2). The poorest decomposition was detected in the two technologically treated plots where it did not fall below 1% C-HS.

Nitrogen is an important element for nutrition. The measured C:N values correspond to the optimum state of its availability and entirely equalize with the values detected on intensively managed plots of agricultural land resources.

Profiles of available nutrients are at a level of above-standard to very high values on the surveyed sites. Particularly the values of magnesium are very high and in the whole profiles they correspond to about 5-times the amount of very high reserve. They are double even for a very high reserve in arable soils. They are very high to nearly marginally hazardous in the lower soil horizons on the untreated plot (BM2), which is specific by partial salinization – likely due to the groundwater contamination. Correlative values of Cl^- and SO_4^{2-} corroborate the hypothesis (Table 6).

Soil salinization above 0.2 mS·cm^{-1} can be considered as slightly increased. At a depth of 80 cm it even approaches the values of salinized soils (0.7 mS.cm^{-1}). The increased content of detected salts may serve to derive an increased content of potassium in the soil although the potassium content in the soil was not analyzed in the laboratory. Salt precipitates are well apparent in these horizons also in the field assessment of partial characteristics. Precipitated salts in these horizons are well apparent also in the field assessment of partial characteristics.

Potassium is an element which among other things provides for the growth and division of cells (e.g. in the root system). Its deficiency results in the hypertrophic development of parenchyma tissues. Moreover, it affects the water regime of plants and enzymic activity (Sakai, Larcher 1987). It is an important macrobioelement in the nutrition. Its proportion to high magnesium content represents a risk, in some cases a very high risk. If the Mg : K ratio in chemical equivalent rises above 10 : 1, the input of potassium in the nutrition is suppressed due to the antagonistic relation. With sufficiently developed biomass in the upper rhizosphere, the risk can be eliminated – especially on the site of the intact soil profile without the soil preparation.

CONCLUSIONS

The paper analyzes the effect of whole-area site preparation by ploughing and agroforestry on the understorey, soil biological activity, and soil physical and chemical characteristics in the commercial forest. Analyzed were 20-years-old stands of pedunculate oak (*Quercus robur* [L.]) on alluvial sites 1L9 (*Fraxino pannonicae-Ulmetum*). A parallel study was conducted to assess the effect of the clearcut size. Conclusions from the conducted analyses are as follows:

- Neither different site preparation nor clearcut size affect the understorey.
- Neither different site preparation nor clearcut size affect the biological activity of soil.
- Agroforestry adversely affects porosity and water-retention capacity in the lower layer (25–30 cm) of top-soil due to recurrent traffic of machines. A single ploughing treatment has a negative effect on the loss of C-substances due to accelerated mineralization. The differences are not of essential character. The values did not fall below the critical levels, and in no case did they affect other monitored site parameters or the development of root systems and aboveground parts of oak trees.

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