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The impact of agricultural land afforestation on soil water content in Central Bohemia

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Abstract: In the Czech Republic, the afforestation of agricultural land has been supported by providing subsidies from the government and the European Union. Afforestation of less-productive agricultural land provides many benefits including carbon sequestration, soil erosion control, biodiversity, water retention, cooling, social benefits, decreasing noise and light pollution, increasing air quality, wind speed reduction, oxygen production, wood production and non-wood products. In some aspects, it is possible to produce wood of the same quality on former agricultural land compared to permanent forest land. In this study, we attempted to find out the course of temperatures and volumetric water content as well as some other physical soil properties (at depths of 20, 40 and 60 cm) 9 years after the afforestation of agricultural land (warm, mild dry region of the Czech Republic) with a mixture of broadleaved tree species (*Quercus robur* L., *Quercus rubra* L. and *Acer platanoides* L.) or monospecific *Pinus sylvestris* L. stand; the study was performed in the period from April to the beginning of November 2020. Concerning the studied physical soil properties, the value of bulk density was higher (and total porosity lower) at a depth of 20 cm in *Pinus sylvestris* L. compared with agricultural land or the mixture of broadleaves; the water stability of soil aggregates was higher after the afforestation with the mixture of broadleaves. The temperature was lower in the soil of afforested plots (at all studied depths) compared to the agriculturally used land. Differences in rainfall interception, transpiration, soil (and forest floor) properties and other factors could influence the obtained values of water content in the soil of the studied plots. The average volumetric water contents were the highest in the plots with Scots pine (depth of 20 cm) and broadleaves (depth of 40 cm), and on the control plot (depth of 60 cm). The volumetric water content at a soil depth of 20 cm was not significantly ($P > 0.05$) different when the plot with Scots pine and agriculturally used land were compared. In all other cases and depths, the differences between plots were significant ($P < 0.05$).

Keywords: Chernozem; forest; physical soil properties; precipitation; soil temperature

Afforestation is one of the methods recommended for practical agriculture to increase carbon sequestration (Středa et al. 2008); some other reasons for the afforestation of agricultural land are unprofitable agricultural production in less fertile soils, soil erosion control, water retention, biodiversity, decreasing noise and light pollution, increasing air quality, oxygen production, wind speed reduction, cooling, social benefits, wood production and non-wood products (Gallo et al. 2020). Vacek et al. (2021b) studied differences between original forest sites and reclaimed sites afforested with Scots pine; Vacek et al. (2021a) compared benefits of introduced versus native species on reclaimed sites. In some aspects, it is pos-

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sible to produce wood of the same quality on former agricultural land compared to permanent forest land, which is significant plus speaking in favour of afforestation; it may become one of the main reasons for further afforestation (Cukor et al. 2020). Vopravil et al. (2015, 2017a) defined criteria (based on soil depth, stoniness, slope, waterlogging, gullies) and identified areas suitable for afforestation of agricultural land in the Czech Republic [see maps in the publications by Vopravil et al. (2015, 2017a)]. The System of Evaluated Soil Ecological Units [described in different publications including Vopravil et al. (2011, 2015)] was used in the selection of the areas suitable for afforestation (see Vopravil et al. 2015); the selection of forest tree species suitable for the above-mentioned afforestation of agriculturally used soils is described in different publications (e.g., Vopravil et al. 2017a). In the Czech Republic, afforestation of agricultural land has been supported by providing subsidies from the government and the European Union (MZe 2018).

Afforestation of agricultural land may lead to changes of physical, chemical and biological properties of mineral soil (and positive effects on air and water protection); it causes the formation of forest floor layers (Holubík et al. 2014; Vopravil et al. 2014) and the characteristics of the plough layer may persist for a long period of time (Vopravil et al. 2014). Bünemann and Condron (2007) mentioned that the afforestation of grasslands leads to lower soil organic matter and nutrient (nitrogen, phosphorus) contents in mineral soil. The authors stated that, as a result of the afforestation of grasslands, concentrations of soil organic carbon decreased by 3–49% and concentrations of organic phosphorus in 0–10 cm mineral soil decreased by 15–22%; in case of organic sulphur, the concentrations decreased by 19–28%. Vopravil et al. (2021) found that the concentration of total organic carbon in mineral soil significantly decreased 1–3 years after the afforestation of agriculturally used soil; the effect was dependent on the given type of soil or tree species. Olszewska and Smal (2008) reported that the afforestation of agricultural land decreased the bulk density and increased the total porosity. Vopravil et al. (2014) stated that the afforestation of agricultural land increased the values of total porosity (and capillary and gravitational pores), decreased the bulk density and led to the improvement of aggregate stability.

The changes of soil temperature with vegetation cover changes were described in scientific literature (e.g., Song et al. 2013). For example, Savva et al. (2010) determined the differences in the values of soil temperature between grasslands and forests (1.4–2.4 °C annually, up to 2.9–5.3 °C in September/June). Afforestation may influence hydrological cycles. For example, increased values of interception and transpiration and reduced values of river and stream runoff etc. were reported by many authors (Jackson et al. 2005); the effect of agricultural land afforestation on water infiltration was reported by Ilstedt et al. (2007) and Hrabovský et al. (2020). For example, Ilsted et al. (2007) synthesised and discussed the effect of afforestation on infiltrability in the tropics; the authors reported the infiltration increased approximately three-fold after afforestation or using trees in agricultural fields. The decrease of soil water content following the afforestation was found by Yao et al. (2016); according to the authors, the soil water content responses to afforestation vary across trees.

In this study, we attempted to determine the effect of agricultural land afforestation (for the period of 9 years) with a mixture of broadleaves or Scots pine on temperature and volumetric soil water content at different depths in the period from April to the beginning of November 2020. We hypothesised lower soil temperature in the soil of afforested land in the course of vegetation season (Bedrna 1977) and different fluctuations of water content in the soil of afforested versus agricultural land in the course of vegetation season (e.g., Ren et al. 2018). Further, we attempted to determine the effect of afforestation on other physical soil properties (the analyses of disturbed and undisturbed soil samples from different soil depths – 20, 40, and 60 cm) using laboratory methods. Based on previous studies (Kupka, Podrázský 2010; Vopravil et al. 2021), we hypothesised that bulk density decreased and porosity increased after the afforestation of agricultural land.

MATERIAL AND METHODS

The experimental plots were established near Hovorčovice, north of Prague in the Czech Republic (Prague-East District), on Haplic Chernozem (IUSS Working Group WRB 2015). This area is characterised by mean annual air temperature of 8–9 °C, by mean annual precipitation of 500–600 mm and the sum of air temperatures above 10 °C between 2 600 and 2 800 (warm, mildly dry region of the Czech Republic). The afforestation of agricultural land with

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different forest tree species was performed in 2011. One of the experimental plots was afforested with Scots pine (*Pinus sylvestris* L.) and the second plot with a mixture of pedunculate oak (*Quercus robur* L.), red oak (*Quercus rubra* L.) and Norway maple (*Acer platanoides* L.). The control agriculturally used plot was also established with cultivation of *Phacelia tanacetifolia* in the year 2020 and a rain gauge (Pronamic Professional Rain Gauge, 200 cm^2, accuracy 0.1 mm, Minikin ERi datalogger, EMS Brno, Czech Republic) was placed on the control plot. The volumetric water content (θ_v) and temperature were continuously measured at depths of 20, 40, and 60 cm on each of the experimental plots using TOMST TMS-4 sensors (TOMST, Czech Republic). The conversion of readings from the sensors to volumetric water content values was performed using the software from the manufacturer (see https://tomst.com/web/cz/systemy/tms/software/ – TMS Calibr Utility); for the calibration curve, several parameters were used including bulk density ($g\cdot cm^{-3}$), sand (%), silt (%), clay (%), volumetric water content measured during the installation of the sensors. The measurement was performed from April to the beginning of November 2020. Disturbed and undisturbed (using a Kopecky cylinder core) soil samples were collected at depths of 20, 40, and 60 cm with three replications. The samples were analysed for physical (particle and bulk density, total soil porosity, maximum capillary water capacity, minimum air capacity, water retention capacity and saturated water content) and chemical (pH_{H_2O} and pH_{KCl}, cation exchange capacity, and base saturation) properties. The values of pH_{H_2O} and pH_{KCl} measured according to the standard ČSN ISO 10390 (2011) and cation exchange capacity and base saturation measured according to ISO 11260 (1994) are shown in Table 1. The textural class (Soil Science Division Staff 2017) is silty clay loam in all plots and soil depths; the only exception is clay loam at a depth of 20 cm on the plot afforested with Scots pine. Some other physical soil properties were measured according to Valla et al. (2000). The water stable aggregates were determined only at a depth of 20 cm according to Kemper and Rosenau (1986); for example, Bacq-Labreuil et al. (2019) reported the effect of *Phacelia tanacetifolia* on aggregate size distribution and porosity was dependent on soil texture.

The differences in the values of studied properties were determined by testing using one-way ANOVA and Tukey HSD test. When the assumptions about parametric tests were not met, non-parametric Kruskal-Wallis ANOVA and Kruskal-Wallis multiple-comparison *z*-value test with Bonferroni correction for multiple testing were used. All statistical analyses were performed with STATISTICA Cz software (Version 10, 2011).

RESULTS AND DISCUSSION

The one-way ANOVA showed that the values of particle density or minimum air capacity were not significantly ($P > 0.05$) different between the experimental plots (Table 2). At a depth of 20 cm, one-way ANOVA and Tukey HSD test showed significantly ($P < 0.05$) higher bulk density in the plot

Table 1. Selected chemical properties of soil on the studied plots

Plot	Soil depth (cm)	pH_{H_2O}	pH_{KCl}	*CEC* ($mmol\cdot 100\ g^{-1}$)	*BS* (%)
Control plot	20	7.77	7.25	24.41	100
	40	7.91	7.30	25.76	100
	60	7.93	7.32	25.45	100
Pedunculate oak + red oak + Norway maple	20	7.61	6.96	26.52	98
	40	7.74	7.09	27.53	100
	60	7.96	7.18	24.98	100
Scots pine	20	7.72	6.99	26.17	100
	40	8.00	7.27	24.50	100
	60	8.17	7.53	n.d.	n.d.

pH_{H_2O} – soil pH measured in water; pH_{KCl} – soil pH measured in 1 $mol\cdot L^{-1}$ KCl at 1 : 2.5 soil (g)/solution (mL) ratio; *CEC* – cation exchange capacity; *BS* – base saturation; n.d. – not determined

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Table 2. Selected physical properties of soil on the studied plots (mean ± standard error)

Plot	Soil depth (cm)	*PD* (g·cm⁻³)	*BD*	*P* (% vol.)	*MAC*	*MCWC*	*WRC*	*PNP* (% rel.)
Control plot	20	2.55 ± 0.01[a]	1.42 ± 0.02[a]	44.24 ± 0.70[a]	6.21 ± 0.47[a]	38.03 ± 1.16[a]	35.07 ± 0.97[a]	11.29 ± 1.45[a]
Pedunculate oak + red oak + Norway maple	20	2.57 ± 0.03[a]	1.48 ± 0.03[a,b]	42.32 ± 0.75[a,b]	5.31 ± 1.11[a]	37.79 ± 0.66[a]	34.96 ± 0.48[a]	10.03 ± 2.77[a]
Scots pine	20	2.59 ± 0.02[a]	1.54 ± 0.02[b]	40.54 ± 0.25[b]	6.85 ± 0.07[a]	35.93 ± 0.14[a]	32.89 ± 0.18[a]	13.13 ± 0.32[a]
Control plot	40	2.62 ± 0.02[a]	1.58 ± 0.02[a]	39.86 ± 1.02[a]	4.44 ± 0.78[a]	35.81 ± 0.23[a]	33.23 ± 0.28[a]	8.01 ± 1.42[a]
Pedunculate oak + red oak + Norway maple	40	2.61 ± 0.05[a]	1.51 ± 0.01[a]	42.12 ± 0.72[a]	8.89 ± 0.65[a]	33.22 ± 0.16[b]	30.51 ± 0.19[a]	18.93 ± 1.17[b]
Scots pine	40	2.66 ± 0.02[a]	1.31 ± 0.02[b]	50.76 ± 0.35[b]	7.31 ± 1.57[a]	50.36 ± 2.37[c]	47.19 ± 3.11[b]	8.86 ± 2.89[a,b]
Control plot	60	2.60 ± 0.01[a]	1.31 ± 0.02[a]	49.58 ± 0.96[a]	14.62 ± 1.42[a]	34.95 ± 0.46[a]	31.37 ± 0.42[a]	24.54 ± 2.34[a]
Pedunculate oak + red oak + Norway maple	60	2.61 ± 0.03[a]	1.37 ± 0.01[a]	47.57 ± 0.85[a]	13.53 ± 1.65[a]	34.68 ± 0.45[a]	31.2 ± 0.46[a]	24.42 ± 2.59[a]
Scots pine	60	2.65 ± 0.03[a]	1.30 ± 0.01[a]	50.95 ± 0.21[a]	17.36 ± 0.77[a]	33.59 ± 0.56[a]	28.66 ± 0.44[a]	28.34 ± 1.08[a]

PD – particle density; *BD* – bulk density; *P* – total porosity; *MAC* – minimum air capacity; *MCWC* – maximum capillary water capacity; *WRC* – water retention capacity; *PNP* – proportion of non-capillary pores in total porosity; a, b – significant ($P < 0.05$) differences between the same depths

with Scots pine when compared with the control agriculturally used plot. At a depth of 40 cm, significantly ($P < 0.05$) lower bulk density was found in the case of Scots pine compared with the mixture of broadleaves or control plot. At depths of 20 and 40 cm, the respective values of total porosity were significantly ($P < 0.05$) lower and higher on the Scots pine plot compared with the mixture of broadleaves and control plot. The values of maximum capillary water capacity were significantly ($P < 0.05$) different only at a depth of 40 cm of all experimental plots. One-way ANOVA and Tukey HSD test showed significantly ($P < 0.05$) higher water retention capacity at a depth of 40 cm of the plot with Scots pine compared with the other plots (Table 2); non-capillary pores accounted for a significantly higher proportion of total porosity at a depth of 40 cm in the mixture of broadleaves compared with the agriculturally used plot. At a depth of 60 cm, the values of particle and bulk density, total porosity, minimum air capacity, maximum capillary water capacity, water retention capacity and proportion of non-capillary pores in total porosity were not significantly ($P > 0.05$) different between the experimental plots (Table 2). The water stable aggregates at a depth of 20 cm were significantly ($P < 0.05$) higher (mean ± S.E. = 0.66 ± 0.003) on the plot with broadleaves compared with the other experimental plots (0.45 ± 0.017 in the control agriculturally used soil and 0.41 ± 0.005 on the plot with Scots pine). From all studied plots, the highest soil organic matter content was found in the soil under broadleaves and it positively influenced the water stability of soil aggregates (Vopravil et al. 2014).

The values of soil organic matter content belong to the main factors influencing bulk density (e.g., Duffková, Kvítek 2009; Ruehlmann, Körschens 2009; Tolimir et al. 2020) and other physical soil properties (Huntington 2007); the decrease of soil organic matter content led to the higher values of bulk density (e.g., Sakin et al. 2011). The values of bulk density also depend on the texture, mineral constituents and porosity (Baver et al. 1972; Vopravil et al. 2017b); correlations of bulk density with total porosity were reported by Hemmat et al. (2010) etc. In this study, the values of bulk density at a depth of 20 cm were significantly higher and the values of total porosity were significantly lower in Scots pine compared to the other studied plots and the opposite was found at a depth of 40 cm

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(including the values of maximum capillary water capacity and water retention capacity). It may be given by a decreased or increased soil organic matter content at depths of 20 cm or 40 cm 9 years after the afforestation of agricultural land with *Pinus sylvestris* L. and differences in soil texture (20 cm) etc. The decreased or increased soil organic matter content after the afforestation of agricultural land with different forest tree species is reported in different publications (e.g., Rytter, Rytter 2020). For example, Kupka and Podrázský (2010) and Kārkliņš and Līpenīte (2013) found that the afforestation of agricultural land with different species led to lower values of bulk density and higher values of total porosity at all studied soil depths.

Significant ($P < 0.05$) differences between all studied plots were found in temperature (the comparison of all studied depths). In the course of the studied period, the temperature was higher in the soil of control agriculturally used plot (all studied depths) compared to the forests. At a depth of 20 cm, the exceptions were some time intervals in the course of certain days (May 11, September 25–26, October 10–11, October 24–25 in the plot with broadleaves as well as September 17–18, October 10–12, October 19–20, October 29–30 in case of Scots pine). At a depth of 40 cm, the same temperature was found in the soil of control agriculturally used plot and Scots pine plot in the course of certain days (October 14, 28 and 29). The maximum and minimum values of soil temperature in the soil of the studied plots are shown in Table 3. The maximum soil temperature was measured at the beginning of July (at a depth of 20 cm) and in August (at depths of 40 and 60 cm) in the agriculturally used plot (Figure 1). In both forest plots, the maximum soil temperature was recorded in August (at all studied depths, see Figures 2 and 3). In the plot with broadleaves and control agriculturally used soil, the minimum soil temperature was measured in October (at all depths, see Figures 1 and 2); the minimum temperatures in October (at a depth of 20 cm) or at the beginning of experiment (depths 40 and 60 cm) were found in the soil of Scots pine plot (Table 3, Figure 3). In the soil of agriculturally used plot, the average temperature (the period from April to the beginning of November 2020) was 16.7 °C (depth of 20 cm), 16.4 °C (depth of 40 cm) and 16.1 °C (depth of 60 cm). The average temperature 14.7 °C (20 cm), 14.2 °C (40 cm) and 14.0 °C (60 cm) was measured in the soil under broadleaves; the average values 14.5 °C (20 cm), 14.3 °C (40 cm) and 14.0 °C (60 cm) were measured on the plot with Scots pine. In the vegetation season, soil temperature is higher in fields (or meadows) compared to forests (Bedrna 1977). Poleno et al. (2011) stated that the average annual temperature of soil surface was 6.5 °C (mixed forest – pine, beech and oak) and 7.7 °C in the field. For example, Michelsen-Correa and Scull (2005) studied differences in soil temperature between forests and fields. Like in our study, the authors stated that field soils were warmer during the spring compared to the soils forested with pines (*Pinus strobus* and *Pinus resinosa*) and deciduous trees (*Fagus americana*, *Acer sac-*

Table 3. Maximum and minimum values of soil temperature and volumetric water content on the studied plots

Plot	Depth (cm)	Soil temperature (°C)		Volumetric water content ($m^3 \cdot m^{-3}$)	
		minimum	maximum	minimum	maximum
Control plot	20	9.06	22.88	0.02	0.50
	40	10.31	20.88	0.30	0.38
	60	11.13	20.25	0.25	0.41
Pedunculate oak + red oak + Norway maple	20	8.75	20.25	0.24	0.41
	40	9.56	18.63	0.22	0.29
	60	10.31	17.75	0.25	0.33
Scots pine	20	8.94	20.13	0.24	0.47
	40	9.63	18.88	0.23	0.43
	60	9.63	17.88	0.19	0.35

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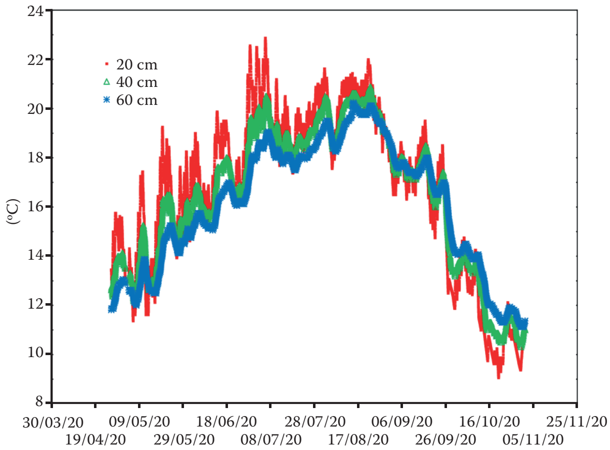

Figure 1. The course of temperatures in the soil of the control agriculturally used plot

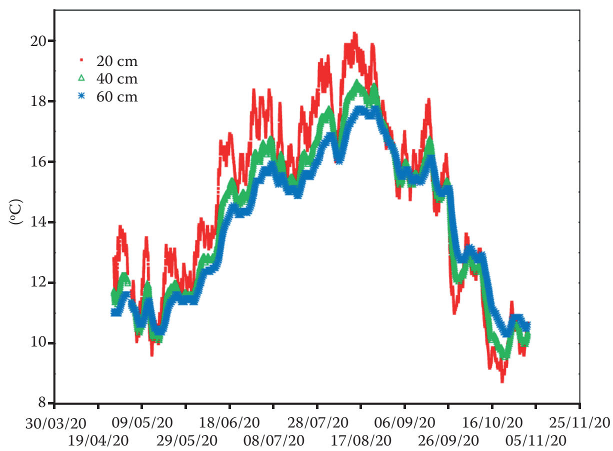

Figure 2. The course of temperatures in the soil of the plot with a mixture of pedunculate oak (*Quercus robur* L.), red oak (*Quercus rubra* L.) and Norway maple (*Acer platanoides* L.)

charum) and they revealed greater temperature variations in field soils. The authors also reported an opposite trend (forested soils warmer than field soils) in autumn (approx. from the middle of November) and in winter. Michelsen-Correa and Scull (2005) also cited some other publications on soil temperature (forested versus cleared soils, the effect of cleared land during winter, the effect of artificial warming etc.).

The value of total precipitation in the period from April to the beginning of November 2020 was 437.4 mm (Figures 4–6). From all studied plots, the lowest average values of volumetric water content at depths of 20 and 40 cm were found on the plot with broadleaves; at a depth of 60 cm, the lowest average volumetric water content was found on the plot with Scots pine. The average values of volumetric water content in the studied soils were 0.32 $m^3 \cdot m^{-3}$ (20 cm), 0.35 $m^3 \cdot m^{-3}$ (40 cm) and 0.34 $m^3 \cdot m^{-3}$ (60 cm) (control plot), 0.28 $m^3 \cdot m^{-3}$ (20 cm), 0.24 $m^3 \cdot m^{-3}$ (40 cm) and 0.28 $m^3 \cdot m^{-3}$ (60 cm) (the plot with broadleaves) and 0.34 $m^3 \cdot m^{-3}$ (20 cm), 0.29 $m^3 \cdot m^{-3}$ (40 cm) and 0.23 $m^3 \cdot m^{-3}$ (60 cm) (Scots pine). The values of volumetric water content at a soil depth of 20 cm were significantly ($P < 0.05$) different when the control agriculturally used plot was compared with the plot with broadleaves or in the comparison of the plots with broadleaves versus Scots pine. No significant ($P > 0.05$) differences were found by the comparison of Scots pine versus agriculturally used plot. At depths of 40 cm or 60 cm, significant ($P < 0.05$) differences were found between all studied plots. The maximum and minimum values of volumetric water content in the soil of the studied plots are shown in Table 3. In the agriculturally used plot, the maximum and minimum values of volumetric water content were measured in August (all depths, see Figure 4). In the soil of the plot with broadleaves, the maximum and minimum values were measured in October and August (20 cm), April and September (40 cm) and May and October/November (60 cm). In the plot with Scots pine, the maximum or minimum volumetric water content was measured in August or May (20 cm), October or May (40 cm) and October or April/May (60 cm).

In different crops or forests (and also shrubs etc.), only some of rain droplets (throughfall and stemflow) reach the soil surface (Poleno et al. 2011). They are evaporated directly from crop canopies (interception) and it also depends on the growth stage of plants as well as the number of plants per area unit etc. (e.g., Stocking 1985; Lin et al. 2020); rainfall interception proportions depend on the type of forest tree species while the highest proportions were reported in fir (80%, total rainfall 500 $mm \cdot year^{-1}$) and the lowest in pine (35%, total rainfall 500 $mm \cdot year^{-1}$) when different forest tree species were compared (pine, beech, spruce and fir). Interception may be higher during the time when the trees have leaves (compared to the time when they have shed leaves) and foliage may significantly influence interception. Vincke et al. (2005) reported interception from 18% to 43% in forest stands (*Quercus robur* plus *Fraxinus excelsior* plus *Quercus rubra* plus *Betula* sp. plus *Acer pseudoplatanus* or stand with *Prunus spinosa*). The value of average

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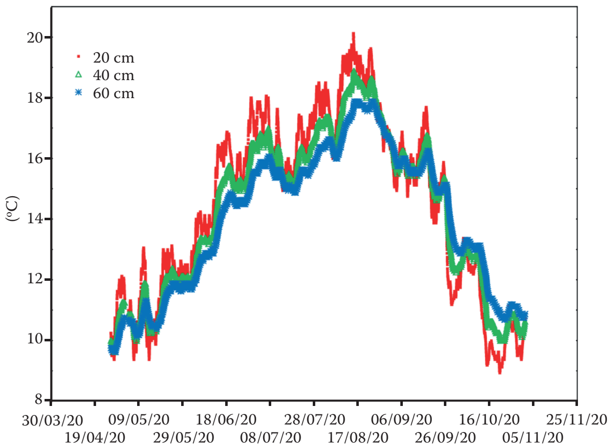

Figure 3. The course of temperatures in the soil of the plot with *Pinus sylvestris* L.

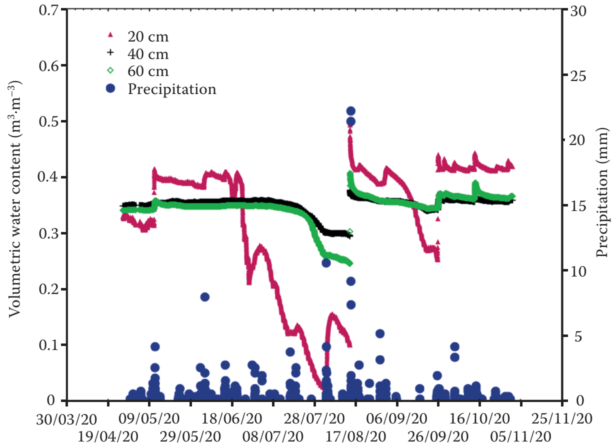

Figure 4. The values of volumetric water content in the soil of the control agriculturally used plot

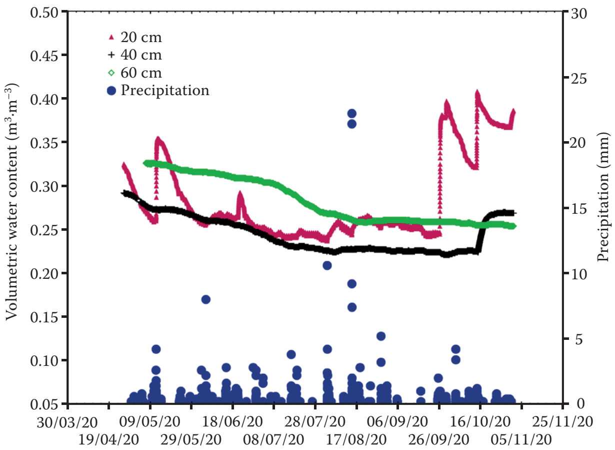

Figure 5. The values of volumetric water content in the soil of the plot with a mixture of pedunculate oak (*Quercus robur* L.), red oak (*Quercus rubra* L.) and Norway maple (*Acer platanoides* L.)

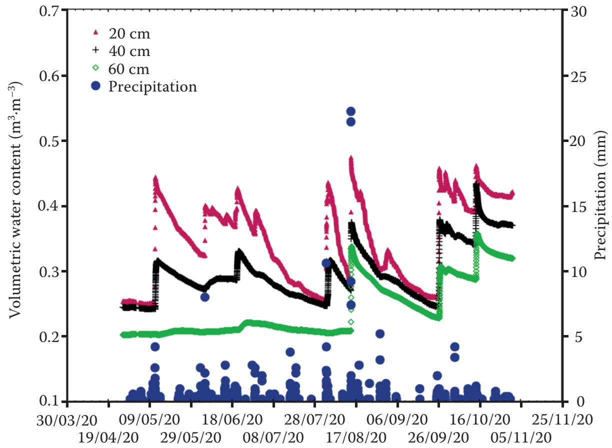

Figure 6. The values of volumetric water content in the soil of the plot with *Pinus sylvestris* L.

rainfall interception of about 27% in *Quercus suber* (the interception varied from 100% to 3%) or interception of 22–41% (ponderosa pine, stone pine in thinned and unthinned areas, *Pinus pinea*), 18% (*Cistus ladanifer*), 28–41% (sessile oak), 20–40% (deciduous forests), 34% (Douglas fir), 21–43% (maple or beech) were reported in different publications (Xiao et al. 2000; Vincke et al. 2005; Mazza et al. 2011; Moreno-Pérez et al. 2018). Reynolds and Henderson (1967) and Moreno-Pérez et al. (2018) showed throughfall to account for 74–78% of precipitation in *Betula* sp., 70% and 65% in *Pinus pinea* and *Cistus ladanifer*. Fang et al. (2016) reported the canopy storage capacity of 1.53 mm in *Pinus tabulaeformis* [1.8 mm and 0.7 mm were reported in *Pinus pinea* and *Cistus ladanifer* by (Moreno-Pérez et al. 2018)], and throughfall in this and other discussed studies on *P. tabulaeformis* ranged from 67.4% to 82.6% of total rainfall, being dependent on the rainfall class; according to the authors the heterogeneity of throughfall decreased with increasing rainfall amount. Compared to precipitation outside of the forest, Reynolds and Henderson (1967) stated that the most evident concentration of rainfall on certain parts of forest floor was found in beech while it was negligible in larch etc. The calculated or measured (natural or simulated rainfall) values of total rainfall intercepted by plant canopies (different crops including maize, cotton, sorghum) in the range from 5% to 80% were presented in different publications (Stocking 1985; Nazari et al. 2020). The difference in rainfall interception proportions

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between tree species (and different crops) may be related to rainfall intensity (e.g., Reynolds, Henderson 1967; Xiao et al. 2000; Cantú Silva, González Rodríguez 2001; Poleno et al. 2011; Nazari et al. 2020), thinning (Mazza et al. 2011) etc. Lin et al. (2020) elaborated a review of 138 studies (scholarly peer-reviewed papers from different databases including Web of Science, BIOSIS etc. or Google Scholar) on rainfall (simulated or natural), sprinkler irrigation water partitioning (interception, throughfall and stemflow) by different crop canopies (> 60 crop species including cereals, potatoes, leguminous crops, vegetables, coffee plantations as well as banana, cacao, guava, cashew etc., the ranges of mean annual temperature and precipitation were 2.2–28.4 °C and 95–4 750 mm·year^{-1}). Lin et al. (2020) reported the interquartile range of 58–83%, 2–26% and 11–32% for throughfall, stemflow and interception, respectively; for example, the highest stemflow producers were cereals (median 33.4% of rainfall) and the crop types dominated by trees were the lowest (fruits, nuts etc., median ca. 2–5%).

The values of forest tree transpiration differ; for example, Poleno et al. (2011) determined the values 2.3–2.5 mm (pine), 2.0–3.8 mm (beech) or 4.3–4.4 mm (spruce) etc. for summer (sunny) day. In forests, the interception of rainfall by the ground vegetation may play a role and the transpiration of trees may be lower (or higher) compared to the forest floor (Vincke et al. 2005 etc.). It was found out by Vincke et al. (2005) in the study on the components of actual evapotranspiration (interception, transpiration and forest floor evapotranspiration) that the forest floor evapotranspiration was up to 26–40% of actual stand evapotranspiration. Putuhena and Cordery (1996) determined the interception storage capacities of forest floor litter (and litter types). The authors described the linear relationships between mass per unit area of the forest floor litter and the interception storage capacities; the influence of stem and branch litter was relatively low compared to leaf litter and grasses. According to Poleno et al. (2011), mull is the most favourable type of forest floor for the entry of water into the mineral soil. Hrabovský et al. (2020) reported that the infiltration rate was significantly higher in vineyard soils (compared to afforested soils) and it increased over time in soils afforested with *Q. petraea* and *C. betulus*. Tesař et al. (2004) reported the soil water content was higher in dwarf pine (peaty soil) compared to Norway spruce (or meadow). The higher values of runoff from the basin in beech compared to Norway spruce (and the higher value of rainfall interception in Norway spruce) or agricultural land compared to forests (mixed stands are more favourable compared to Norway spruce) were reported (van der Salm et al. 2006; Poleno et al. 2011). In this study, the response of soil water content to precipitation was less visible in the plot with broadleaves compared with the other plots. Probably, differences in rainfall interception (trees and other plants, litter) in the course of the studied period, rainfall concentration, differences in transpiration (trees and ground vegetation, crops) and properties of the forest floor layer as well as soils may play a role.

CONCLUSION

From particle and bulk density, total porosity, maximum capillary water capacity, minimum air capacity, water retention capacity and non-capillary porosity, the afforestation significantly ($P <$ 0.05) influenced some of these soil properties at a depth of 20 and 40 cm (not 60 cm). In afforestation with *Pinus sylvestris* L., the values of bulk density were higher (and total porosity lower) at a depth of 20 cm and lower (and total porosity higher) at a depth of 40 cm compared with agricultural land or the mixture of broadleaves; the water stability of soil aggregates (measured only at a depth of 20 cm) was higher after the afforestation with the mixture of broadleaves. The temperature was lower in the soil of afforested plots (at all studied depths) compared to agriculturally used soil; the differences between individual plots were significant ($P < 0.05$) at all soil depths. The fluctuations of water content in the soil of the plot with broadleaves or Scots pine plot versus agricultural land were different in the course of the studied period. The average volumetric water contents were the highest in the plots with Scots pine (depth of 20 cm) and broadleaves (depth of 40 cm), and on the control plot (depth of 60 cm). The volumetric water content at a depth of 20 cm was not significantly ($P > 0.05$) different between Scots pine and agriculturally used plots. In all other cases and depths, the differences between plots were significant ($P < 0.05$). The obtained results indicate benefits speaking in favour of afforestation.

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