Influence of mineral and bio oil on the germination of acorn and the growth of pedunculate oak (Quercus robur l.) seedlings

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INFLUENCE OF MINERAL AND BIO OIL ON THE GERMINATION OF ACORN AND THE GROWTH OF PEDUNCULATE OAK (*Quercus robur* L.) SEEDLINGS

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Abstract

The purpose of this study is to research the effects of different concentrations of mineral and biodegradable lubricants for chainsaws upon seedling growth and the initial growth of pedunculate oak (*Quercus robur* L.), the most significant forest tree species in the region of the lowland Croatia. Tests were carried out in two nurseries upon 1-m^2-plots (altogether 28 test plots and two control ones) by spilling biodegradable oil and mineral oil, each in three concentrations (0,1 l/m^2, 0,2 l/m^2, 0,5 l/m^2).The analysis showed that the increased concentration of mineral oil may decrease seedling germination; on the contrary, the bio-decomposable oil can increase it.

Due to the insufficiently expressed dependence between the root collar diameter and the oil concentration, the analysis should include the research on other factors. Based on pedological research, we may conclude that the soil of weedy plots is biologically more active, which results in faster oil degradation.

Key words: *Pedunculate oak (Quercus robur L.), mineral oil, biodegradable oil, seedling growth.*

Abstrakt

Cieľom práce je posúdenie efektu rôznych koncentrácií minerálnych y biodegradovateľných mazív pre reťaze motorových píl na rast semenáčikov a počiatočných rastových fáz duba letného (*Quercus robur* L.), ako najvýznamnejšej dreviny regiónu nížin Chorvátska. Test sa uskutočnil vo dvoch lesných škôlkach na 1m^2 veľkých plochách (dohromady 28 testovacích a dve kontrolné plochy) tak, že sa na plochách rozlial olej v troch rôznych koncentráciách (0,1 l/m^2, 0,2 l/m^2, 0,5 l/m^2). Analýza ukázala, že s rastúcou koncentráciou minerálneho oleja klesá vzchádzanie semenáčikov, naopak, použitie biodegradivateľného oleja vzchádzanie zvyšuje. Kvôli nedostatočne preukaznej závislosti medzi hrúbkoukoreňového krčka a koncentráciou oleja, analýza by mala zahrnúť aj výskum iných faktorov. Na základe výsledkov pedologického výskumu môžeme usúdiť, že pôda na vlhkých plochách je biologicky aktívnejšia, čo spôsobuje rýchlejší rozklad olejov.

Kľúčové slová: *dub letný (Quercus robur L.), minerálny olej, biodegradovateľný olej, rast semenáčikov*

INTRODUCTION AND AIM OF THE RESEARCH

Oils for lubricating the power chainsaw chains are called "Total Loss Oils", because they end completely and irreversibly in sawdust, upon timber surface and the soil, or arrive on the surface of leaves of the surrounding plants. According to the research (SKOUPÝ and ULRICH 1994) carried out during the felling and processing of trees, the highest concentration of oil spilled from chainsaws is found in the centre of the stain (0,55 to 0,60 g/m^2), decreasing towards its edge, where there is less than 0,05 g/m^2. Using the radio-indicator method, SKOUPÝ (2004) established that 75%–77% of the oil was absorbed by sawdust, 7%–13% adhered to the surface of cut timber, while 12%–16 % ended upon the soil surface.

The use of biodegradable oils on the cutting parts of chainsaws is the requirement of the time we live in, as numerous demands aimed at preserving biodiversity and natural conditions of the eco-systems (AUGUŠTIN *et al.* 2000) have to be observed. Biodegradable chainsaw oils appeared in 1986. They can be made either of base-fluids of artificial origin (saturated and unsaturated esters), or of natural vegetable oils and animal fats. The most common base-fluid is rape oil, though other base-fluids can also be used. At present, pine oil, also named tall oil, is being investigated in Finland (TAKALO & LAUHANEN 1994).

It has been assessed that the total quantity of chainsaw lubricants discharged into the environment in Finland amounts to 2 million litres where, due to highly mechanised felling and processing, unit consumption ranges between 0,015 l/m^3 and 0,027 l/m^3. According to ANON (1996), in Croatia this quantity is about 420,000 litres per year, with a unit consumption of 0,168 l/m^3. HORVAT i ŠUŠNJAR (2003) established a considerably lower unit consumption of biodegradable and mineral oil for lubricating chainsaw chains. Thus, in the final cut of pedunculate oak they used 0,07 l/m^3; in the thinning of beech stands the respective amount was 0,04 l/m^3, while 0,035 m^3 was required for the selective cut of fir stands.

TAKALO and LAUHANEN (1994) established considerably lesser wear of the lower parts of chain teeth when the chain was lubricated by biodegradable oil, than when it was lubricated by mineral oil. However, their low oxidation stability requires low operating temperatures. Oil viscosity is inversely proportionate to the temperature, so that problems can arise with the lubricant flow quality. During winter and in the summer, the incidence of too abundant lubrication is possible due to decreased operating viscosity of the oil. The use of additives with biodegradable oils can improve their viscosity index and other lubricant characteristics.

LAUHANEN *et al.* (2000) treated plants with biodegradable oils in the laboratory and found no harmful effects. However, at the same time, interviewed operators who used mineral and biodegradable oils reported a much higher number of skin and allergic diseases when biodegradable oils were used.

While investigating the impacts of spilling two concentrations (0,002 l/m^2 and 4,0 l/m^2) upon the germination of Scots pine (*Pinus sylvestris* L.) seeds in glasshouse over three weeks, LAUHANEN and KOLPPANEN (2003) established that smaller concentrations of both oil types decreased the germination, while mineral oil was less suitable. A higher concentration (4 l/m^2)), which corresponds an incidental oil spilling, was lethal for all seeds. The authors also claim that the studied hydraulic oils were more harmful to seeds than chain oils had been found earlier. Considering the harmful impacts of oil upon the soil and plants, a film is formed upon the surface composed of firm particles. The film prevents the contact of the particles with water and air. Impeded breathing of the roots, metabolic disorders, and even root dieback were the established consequences (BAŠIĆ *et al.* 1999). At the same time, the microbiological activity of the soil was decreasing, while the proportion of anaerobic bacteria suddenly increased and the quantity of aerobes decreased. This was partly a consequence of the C:N proportion at the expense of nitrogen. Furthermore, the redox potential was decreasing, while the compounds of iron, manganese, sulphur, etc. were reduced, creating the conditions for their increased mobility.

Accordingly, the purpose of this study is the research on the impacts of different concentrations of both mineral oils and biodegradable ones upon the nursery germination of the acorn, i.e. the initial seedling growth of pedunculate oak (*Quercus robur* L.), the most significant forest tree species of the lowland Croatia.

RESEARCH AREA

The experiment was set in two nurseries, Šumski Vrt of the Zagreb Forestry Faculty and Lukavec, situated in the area of the Forest Office of Velika Gorica. According to Köppen's and Thorntwait's climate division, the nurseries Šumski Vrt and Lukavec belong to the region of moderate warm rain climate marked «Cfwbx».

In both nurseries, the soil is classified as lowland pseudogley (stagnosol). In the upper 30cm, the soil is by its texture a clayey loam. Deeper down, it acquires a slightly heavier texture, and turns into light clay. In the nursery of Šumski Vrt the soil has a neutral to slightly alkali reaction, while the soil reaction in Lukavec is between neutral and slightly acid. In both cases, the upper 10 cm of the soil is moderately supplied with humus. In the Lukavec nursery the contents of the organic matter in relation to the soil depth decreases faster than it is the case in Šumski Vrt. We can generally say that down to the depth of 50 cm the soil in Šumski Vrt is considerably richer in humus than it is the Lukavec soil.

The elevation above the sea level in Lukavec is between 110 m and 120 m, the one of Šumski Vrt is round 123 m. The air distance between the two nurseries is only 14,5 km.

MATERIAL AND METHODS

Each of the two nurseries contained fourteen 1m^2 test plots. The first planting of the pedunculate oak acorns was carried out in the Šumski Vrt nursery on 30th March, and was followed by another in Lukavec on 6th April 2005 of the same year. One group of seven test plots was planted with 1.4 kg acorns: 379 pieces in Lukavec and 351 pieces in Šumski Vrt. The acorns were covered by the soil from the respective nursery, the layer measuring two acorn diameters. Upon covering the seeds, the plots were treated with different concentrations of biodegradable and mineral *Stihl* oils. Using a compressor and sprinkler, the oil was evenly sprayed over the test plots. Three plots were treated with biodegradable oil in the concentrations of 0,1 l/m^2, 0,2 l/m^2, and 0,5 l/m^2. Another three plots were treated with mineral oil of the same concentrations. Six test plots were treated with the same concentrations of both biodegradable and mineral oils without seed sowing. The control plot received only seed sowing, while another plot remained empty. In order to determine physiographic soil properties, soil samples were taken from three different depths (0–10 cm, 10–30 cm, and 30–50 cm) of the test plots in both nurseries. The samples were taken from the plots that had not been treated with oil.

Five months after treating the test plots with oil (September 15th), we took samples from a depth of 10 cm to form a composite sample consisting of five individual ones. The samples were taken with a sonde. Two samples were taken from the diagonal plot (each from the middle of the semi-diagonal), while one was taken from the centre of the plot. The samples were homogenised and stored in a freezer. The content of lipophyl matter (total fats) and mineral oils were analysed on two occasions in the Institute for Public Health of the City of Zagreb.

In order to determine the germination capability of the acorn and to monitor its growth, sprouts were counted on the test plots – twice in the Lukavec nursery, and four times in Šumski Vrt. Upon completed germination, the height and the root collar diameter of the seedlings were measured. The root collar diameter was measured by using a digital movable measurer of an accuracy of 0,01 mm, while the heights were measured with a measuring rod, the accuracy of which was 1 mm. During vegetation, the usual nursery tending routine was carried out. The SAS and Statistica 7 program packages were used for the statistic data processing.

Tab. 1 Physiographic soil properties

Forest nursery	Soil depth [cm]	Coarse sand 2,0 – 0,2 mm	Potty sand 0,2 – 0,02 mm	Silt 0,02 – 0,002 mm	Clay <0,002 mm	Texture mark	C org [g kg^-1]	pH in H_2O	pH in $CaCl_2$
Lukavec	0–10	9,6	37,6	31,2	21,6	clayey loam	18,4	7,54	7,04
	10–30	10,9	34,3	30,2	24,6	clayey loam	17,5	7,73	7,19
	30–50	0,8	41,9	31,8	25,5	clay	13,3	7,57	7,09
Šumski Vrt	0–10	3,0	39,9	36,5	20,6	clayey loam	17,2	7,16	6,85
	10–30	2,9	37,6	41,2	18,3	clayey loam	11,8	7,27	6,82
	30–50	1,1	35,9	36,8	26,2	clay	4,5	6,82	6,52

RESEARCH RESULTS

The results show that the oil remnants in both nurseries coincide. Significantly, the remaining oil in the upper 10 cm of the soil on the bio oil treated plots was at a natural level five month upon the treatment, while the remaining oil corresponded with the treatments. The remaining oil in the soil of the plots treated with 0,5 l/m^2 mineral oil and planted with acorns was at the level of medium load (Toti *et al.* 1998). The remaining oil on the weedy plots was at the level of between low and medium load. Interestingly, the remaining oil on the weedy plots that had been treated with 0,5 l/m^2 oil was very similar to the remaining oil on the acorn planted plots that had been treated with 0,2 l/m^2 oil. These two plot groups evidently have in common a smaller quantity of remaining oil than the plots that had been treated with 0,5 l/m^2, and then planted with acorn.

Tab. 2 Oil remnants in the soil 5 months after treatment

Oil concentration	Type of oil	Plots with seedlings	Forest nursery Lukavec Lipophyll agents mg/kg	Oil hydro-carbons	Forest nursery Šumski Vrt Lipophyll agents mg/kg	Oil hydro-carbons
0,5 l/m^2	Bio	+	32,9	6,8	37,3	7,6
		–	95,5	7,7	103,2	8,4
	Mineral	+	1306,3	784,5	1457,2	810,3
		–	621,4	339,4	758,5	419,6
0,2 l/m^2	Bio	+	18,5	4,1	25,1	4,9
		–	75	3,5	85,1	4,9
	Mineral	+	630,5	367,8	697,2	411,8
		–	109,1	61,3	139,7	83,2
0,1 l/m^2	Bio	+	16,3	2,2	15,7	2,4
		–	20,3	2,5	23,5	3,1
	Mineral	+	56	26,7	73,1	38,3
		–	47,5	30,9	59,1	37,4
0	0	+	17,1	1,4	19,3	2,1
		–	19,4	3,2	22,7	3,8

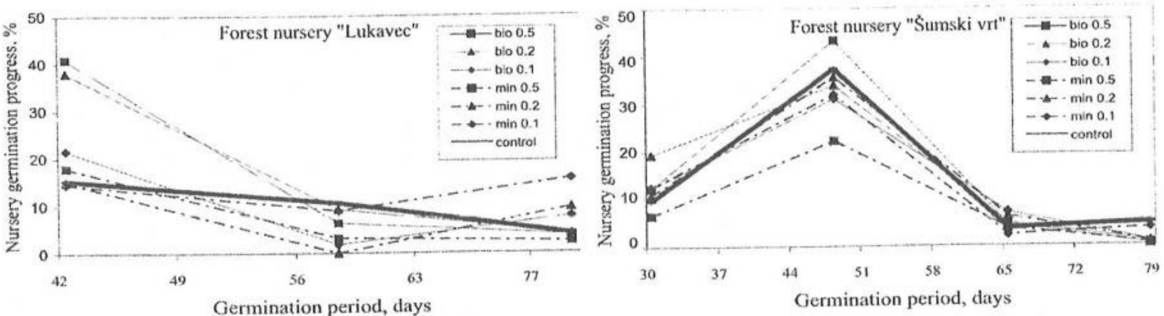

Fig. 1 The course of nursery germination of pedunculate oak (*Quercus robur* L.) acorn on the test plots m^2

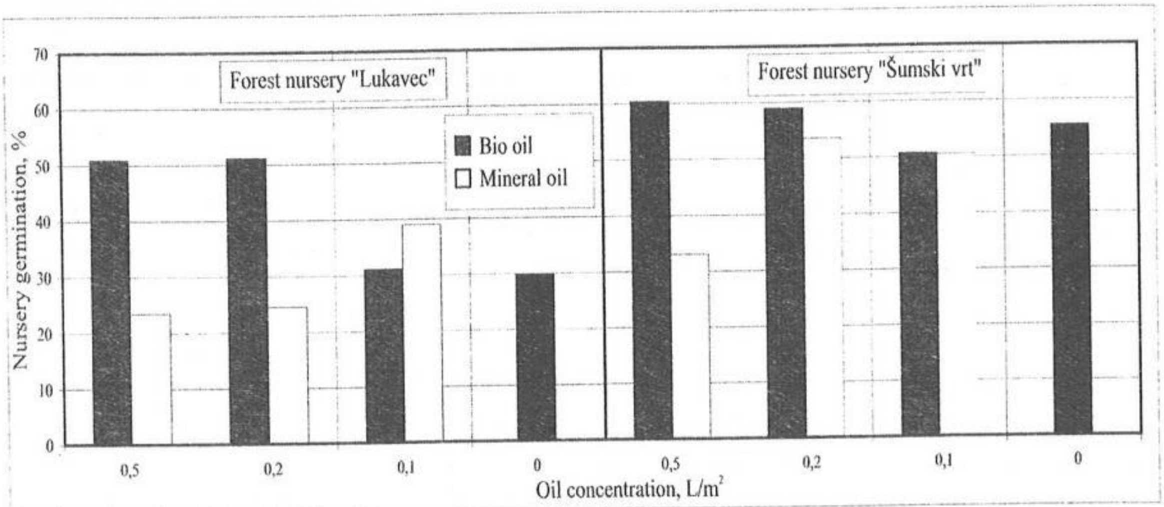

Fig. 2 Nursery germination of pedunculate oak (*Quercus robur* L.) on the test plots

The remaining oil on the plots that had been treated with 0,2 l/m^2 oil and then left to weediness was on a low level, and although considerably higher than the remaining oil on the plots treated with 0,1 l/m^2 oil, it is considered as normal content of hydrocarbon (DUMITRU *et al.* 1998). There are no significant differences between the plots treated with 0,1 l/m^2, either planted with acorn, or left to weediness.

Figure 1 shows the course of nursery germination of the pedunculate oak acorn on the test plots in the nurseries Šumski Vrt and Lukavec. The results of the first sprout counting show certain regularity in both nurseries, i.e. the acorn germination energy on the plots treated with bio oil, regardless of the dosage, was on the average higher than the seed germination energy on the plots treated with mineral oil and control plot respectively.

Figure 2 shows the total nursery germination of pedunculate oak (*Quercus robur* L.) acorn on the test plots of the nurseries of Šumski Vrt and Lukavec. The best acorn germination in both nurseries was achieved on the test plot that had been treated with 0,5 l/m^2 biodegradable oil. The poorest germination in the same two nurseries was found on the test plot treated with 0,5 l/m^2 mineral oil. The average nursery acorn germination on the test plots treated with bio oil was by 11,01% higher in the Šumski Vrt nursery and by 15,39% in Lukavec, when compared with the nursery germination on the mineral oil treated plots. The acorn germination on the control plot in Šumski Vrt was by 26.87% better than the one in the Lukavec nursery.

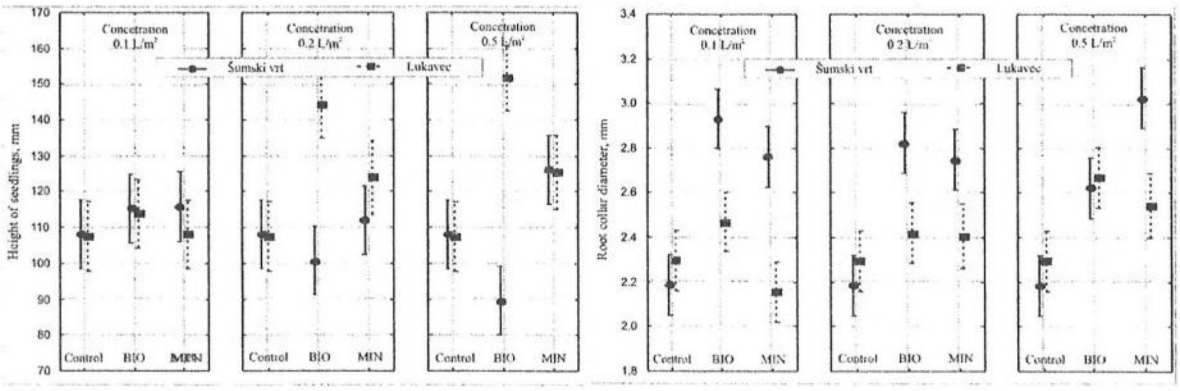

Fig. 3 The first measurement of heights and root collar diameters of pedunculate oak (*Quercus robur* L.) seedlings on the test plots

Tab. 3 Proportion test for nursery acorn germination upon test plots

Type of oil		Biodegradable			Mineral			Control
Concentration (l/m²)		0,5	0,2	0,1	0,5	0,2	0,1	
Lukavec	p	**< 0,0001***	**< 0,0001***	0,765	**0,0293***	0,1236	**0,0093***	113
Šumski Vrt	p	0,2834	0,4217	0,1846	**< 0,0001***	0,5945	0,1117	195

*Significant at $p < 0,05$

According to the proportion test, in the Šumski Vrt nursery a significant acorn germination difference was confirmed only in the case when the soil was treated with 0,5 l/m² of mineral oil – compared to the control plot. In the Lukavec nursery, a significant difference was established when the soil was treated with 0,5 l/m² and 0,2 l/m² bio oil, and with 0,5 l/m² and 0,1 l/m² mineral oil – compared to the germination on the control plot (Tab. 3). Figure 3 presents the results of the first measurement of the heights and root collar diameters of pedunculate oak (*Quercus robur* L.) seedlings upon the test plots of the nurseries Šumski Vrt and Lukavec.

Statistically significant differences between seedling heights at first measurement were established between the following: nurseries; treatment; dose; nursery x treatment; nursery × dose, and nursery × treatment × dose, while no such differences were established only with treatment × dose. The differences of root collar diameters were established in all cases. The arithmetic means of the seedling heights, in both nurseries, was the highest on the test plots that had been treated with bio oil (119 mm). This is followed by the seedling height treated with mineral oil (118 mm), and the one on the control plot (107 mm). The arithmetic means of the root collar diameter in both nurseries was also the highest on the bio oil plots (2,66 mm), followed by those on the plots treated with mineral oil (2,62 mm) and the control plot (2,24 mm).

The average biggest seedling heights in the Lukavec nursery were measured on the plot treated with 0,5 l/m² bio oil, while the lowest heights were found on the control plot. The seedlings in the Šumski Vrt nursery were the highest on the average on the plot treated with 0,5 l/m² mineral oil. The smallest seedling heights in this nursery were measured on the plot treated with 0,5 l/m² bio oil, unlike the Lukavec nursery, were they reached the biggest heights. The seedling heights on the control plot in both nurseries were identical (108 mm).

The biggest average root collar diameter was established in the Lukavec nursery on the plot treated with 0,5 l/m² bio oil, while the smallest heights were measured on the plots treated with 0,1 l/m² mineral oil. The seedlings on the control plot in the Lukavec nursery had root collar diameters of 2,29 mm, while the ones in Šumski Vrt were 2,19 mm high.

The seedlings in Šumski vrt had the biggest average root collar diameter on the test plot treated with mineral oil (0,5 l/m^2). The smallest root collar diameters were measured on the control plot of Šumski vrt.

DISCUSSION AND CONCLUSIONS

The research on the spilling impacts of three concentrations ((0,1 l/m^2, 0,2 l/m^2, and 0,5 l/m^2) of two different chain saw lubrication oils (biodegradable and mineral) upon nursery test plots revealed that neither concentration of the spilled biodegradable oil decreased significantly the germination of pedunculate oak seeds. On the contrary, the germination in one of the nurseries was even increased. The decrease of the nursery germination was established with the highest concentration of mineral oil in both nurseries, as well as with a medium concentration in one of them.

This analysis showed that a higher concentration of mineral oil might decrease the germination, while biodegradable oil can even increase it. The analysis of the seedling height measurement did not clearly show the impacts of the oil type. In one of the nurseries (Šumski Vrt), the plant height decreased proportionally with the concentration of biodegradable oil, while in another (Lukavec) the plant height grew in proportion with the concentration of biodegradable oil. Negligible dependence of the plant height on the mineral oil concentration was established in both nurseries.

In addition to the location, the type of oil also affects the root collar diameter. Except for a single case, the plants treated on the test plots with biodegradable oil developed a slightly bigger root collar diameter, when compared to the control plot and the plots with mineral oils.

The insufficiently clear dependence between the height and root collar diameter on the type and concentration of oil requires the research on other factors.

Based on pedological research, we can conclude that the soil on weedy plots is biologically more active, which leads to faster oil degradation, particularly if the concentrations are higher. Bigger quantities of oil in Šumski Vrt are related to heavier texture, i.e. poorer aeration and more frequent organic-mineral links, and bigger original contents of organic matter. The rhizosphere of the weed species densely penetrates the soil, stimulating the microbiological activity, which is reflected upon the use of energy from hydrocarbon.

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