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PRELIMINARY STUDY ON THE INFLUENCE OF ORGANIC FERTILIZATION AND MULCHING ON THE GROWTH OF ONE-YEAR OLD SCOTS PINE (*PINUS SYLVESTRIS* L.) SEEDLINGS AND OCCURRENCE OF SOIL MITES UNDER MICRO-SPRINKLER IRRIGATION IN TWO DIFFERENT SYLVAN-NATURAL REGIONS OF POLAND

Summary

The aim of the study was to determine the influence of mulching and organic fertilization on the seedling vigour of Scots pine and occurrence of soil mites (Acari) in forest- and post-arable soils. Two different field experiments were carried out in the vegetation period of the year 2005 on light soils at two different sylvan-natural regions. The first trial was conducted at Białe Błota near Bydgoszcz – on a brown podzolic soil. The second experiment – at Lipnik near Stargard Szczeciński – on an acid brown soil. The experiments were run in a *split-plot* system with four replications. Two different factors were compared. The first row factor was fertilization, used in the two following treatments: N_1 – treated sewage sludge (⅔) + bark (⅓) and N_2 – treated sewage sludge (⅔) + sawdust (⅓). The second row factor was mulching, used in the two variants: C – without mulching (control) and S – mulching with litter. Scots pine seedlings grown on the forest soil at Białe Błota were characterized by increased height than those cultivated on the post-arable land at Lipnik. The best results, both on the forest soil as well as on the post-arable ground, were obtained in the case of treatment SN_1 (plots mulched with litter and fertilized with treated sewage sludge (⅔) with bark admixture (⅓)). The higher was the rainfall amount during the vegetation period, the lower was the seasonal irrigation rate supplied to the Scots pine seedlings. Because of this the seasonal irrigation water rate applied at Białe Błota was higher than that at Lipnik. Fresh mass of the above-ground parts of the Scots pine seedling was higher on the forest soil as compared to that on the post-arable land. The seedlings grown on the

treatments mulched with litter were characterized by higher root mass in comparison to those on the control plots (without mulching). Mulching with litter influenced the general number of mites, the number of oribatid mites as well as their species diversity. Organic fertilization (treated sewage sludge with bark or with sawdust) did not influence these indices.

Key words: one-year old Scots pine seedlings, sewage sludge, bark, sawdust, Acari, Oribatida, micro-sprinkler irrigation

INTRODUCTION

Soils changed by industrial or agricultural activities, for instant post-arable grounds, are very often characterized by lack of suitable phyto- and zoo-edaphon which can secure the proper growth of forest trees. Similar situation is noted on soils of older forest nurseries, where a decrease of biological diversity is detected, for example in case of ectomycorrhizal fungi [Aleksandrowicz-Trzcińska 2004]. The problem is connected with excessive alkalization of soil, fertilization, pesticide application and mechanical soil cultivation. It is potentially possible, use the edaphon for intensification of soil processes and also for an increase of biological balance on a post-arable land and grounds of degraded forest nurseries. Therefore, an inoculation of edaphon derived from a forest soil to the soils of nurseries as well as to post-arable grounds, seems to be justified. This treatment should advantageously influence on growth conditions of young trees. According to the opinion of Szujecki [1996], saprophage organisms play especially important role in an edaphon inoculation. In forest soils, the saprophage oribatid mites (Acari, Oribatida) are especially abundant [Klimek 2000]. They play a number of important tasks in soils.

An organic matter is a soil component being decisive in case of soil suitability for seedling cultivation at forest nurseries [Niski 1992]. Proper seedling growth on a soil in forest nurseries is very often determined by supply of organic fertilizers such as composts. In these investigations the compost produced from the treated sewage sludge with admixture of bark or sawdust was applied. Usage of treated sewage sludge is justified from an ecological point of view [Siuta and Wasiak 2001].

The aim of the study was to determine the influence of mulching and organic fertilization on the seedling vigour of Scots pine and occurrence of soil mites (Acari) in the forest- and post-arable soils.

MATERIAL AND METHODS

Two different field experiments were carried out in the vegetation period of the year 2005 on the light soils at two different sylvan-natural regions. The first trial was conducted at Białe Błota near Bydgoszcz – on a brown podzolic

soil; the second experiment - at Lipnik near Stargard Szczeciński - on an acid brown soil.

The experiments were run in a *split-plot* system with four replications. Two different factors were compared. The first row factor was fertilization, used in the two following treatments: N_1 – treated sewage sludge (⅔) + bark (⅓) and N_2 – treated sewage sludge (⅔) + sawdust (⅓). The second row factor was mulching, used in the two variants: C – without mulching (control) and S – mulching with litter.

The plot area was 2 m^2. Total number of plots in each experiment was 16 (2x2x4).

Organic fertilizer was produced on the base of treated sewage sludge (⅔) and Scots pine bark (⅓) or sawdust (⅓). This fertilizer was applied with the dose of 100 $t \cdot ha^{-1}$ in spring and mixed with the topsoil (10 cm deep) before Scot pine seed time.

Mulching with litter obtained from fresh coniferous forest was done – after emergence of Scots pine seedlings – with the dose of 100 $m^3 \cdot ha^{-1}$.

Irrigation was done with the use of micro-sprinklers "Nelson". Terms of irrigation and water rates were established according to [Pierzgalski *et al*. 2002].

In October the growth of plants was evaluated. The height of seedlings was measured as well as the fresh mass of above-ground parts and roots were determined .

The soil samples for investigation on mites were taken three times a year (in May, August and October). The samples of 17 cm^2 area and 3 cm deep were taken from all plots in 3 replications. There were 36 soil samples for each treatment (variant of the experiment). The mites were extracted from the material in high gradient Tullgren funnels, and next they were preserved and prepared. Oribatid mites (including the juvenile stages) were determined to species. Total number of mites was also determined. In general, 2044 mites (Acari) were examined, including 1175 Oribatida. The density of mites *N* was calculated for 1 m^2 of soil area. The species diversity of oribatid mites was determined with the use of general species number *S*, mean number of species in a sample *s* as well as the Shannon index of species diversity *H* [Magurran 1988]. The data of mites were ln-transformed prior to the analyses [Bruchwald 1997].

RESULTS AND DISCUSSION

Course of weather and irrigation

Air temperature in the experiment at Białe Błota

Mean air temperature value of the vegetation period 2005 at Białe Błota was 14.2 °C. It was lower by 0.2 °C than the long-term average. Mean monthly values of air temperature varied from 7.4 °C in April to 19.4 °C in July (Table 1). July was characterized by the highest decade values of air temperature which varied from 18.5 °C to 20.5 °C, in 3rd and in the 2nd decade, respectively.

Table 1. Meteorological conditions of the vegetation period 2005 at Białe Błota and Lipnik

Specification	Months of the vegetation period					
	IV	V	VI	VII	VIII	IX
Air temperature (°C)						
Białe Błota						
1st decade	6.9	10.0	12.3	19.5	15.3	18.1
2nd decade	9.1	9.1	15.2	20.2	16.0	13.6
3rd decade	6.2	17.1	17.3	18.5	17.4	12.9
Mean 1-3	7.4	12.2	14.9	19.4	16.3	14.8
Deviation from the long-period average (%)	-6.3	-6.9	-6.9	+4.9	-8.9	+12.1
Lipnik						
1st decade	8.0	11.7	13.4	18.8	15.8	18.6
2nd decade	10.8	9.9	15.3	20.2	16.8	14.4
3rd decade	8.8	17.9	18.7	19.3	17.1	13.4
Mean 1-3	9.2	13.1	15.8	19.4	16.6	15.5
Deviation from the long-period average (%)	+27.8	+4.8	-0.6	+11.5	-2.4	+17.4
Rainfall (mm)						
Białe Błota						
1st decade	3.8	46.6	20.9	-	19.3	-
2nd decade	1.5	13.2	6.1	2.5	1.6	7.9
3rd decade	18.5	9.7	3.7	37.7	-	10.0
Total 1-3	23.8	69.5	30.7	40.2	20.9	17.9
Deviation from the long-period average (%)	-13.4	+72.4	-41.4	-36.3	-65.2	-60.0
Lipnik						
1st decade	6.6	28.2	13.2	14.4	40.1	-
2nd decade	-	14.1	12.5	14.7	3.4	20.0
3rd decade	7.1	25.2	-	47.1	9.7	5.8
Total 1-3	13.7	67.5	25.7	76.2	53.2	25.8
Deviation from the long-period average (%)	-63.8	+32.1	-58.0	+20.6	-2.4	-45.0

Air temperature in the experiment at Lipnik

Mean air temperature value of the vegetation period 2005 at Lipnik was 14.9 °C. It was 0.7 °C higher as compared to that at Białe Błota. All the months of the vegetation period, excepting July, were characterized by higher temperature in comparison to the values noted at Białe Błota. Mean monthly values of

temperature ranged from 9.2 °C in April to 19.4 °C in July. In the case of July, the decade values of temperature varied from 18.8 °C to 20.5 °C, in the 1st and in the 2nd decade, respectively.

Rainfall in the experiment at Białe Błota

The total rainfall during the vegetation period 2005 amounted 203 mm. It was lower by 76 mm from the long-term average value. The mean monthly rainfall amount in the vegetation period varied from 17.9 mm in September to 69.5 mm in May (Table 1). Among particular decades, there were three decades (1st decade of July, 3rd of August and 1st of September) without rainfall.

Rainfall in the experiment at Lipnik

The total rainfall from 1 April to 30 September amounted 262.1 mm. This amount was higher by 59.1 mm than that at Białe Błota. Among the months of the vegetation period, July was characterized by the highest rainfall amount (76.2 mm), and April by the lowest one (13.7 mm). There were also three rainfall-free decades during the vegetation period: 2nd decade of April, 3rd decade of June and the 1st decade of September.

Irrigation

Amounts of irrigation water were dependent on the course of rainfall and rainfall amounts during the vegetation period. The higher was the rainfall amount, the lower was the seasonal irrigation rate supplied to the Scots pine seedlings. Therefore, the seasonal irrigation water rate applied at Białe Błota was higher (210 mm) than that at Lipnik (140 mm).

Growth of seedlings

Height of seedlings

The Scots pine seedlings grown on the forest soil at Białe Błota were characterized by higher height (10.97 cm) than those cultivated on the post-arable land at Lipnik (8.92 cm) (Table 2). The best results, both on the forest soil as well as on post-arable ground, were obtained in the case of treatment SN_1. Seedlings on plots mulched with litter and fertilized with treated sewage sludge (⅔) with bark admixture (⅓), were characterized by the heights of 12.15 cm and 10.63 cm, on forest- and post-arable soil, respectively. A positive effect of fertilization with sewage sludge with peat admixture on the growth of Scots pine seedlings was noted in our previous investigations [Rolbiecki *et al*. 2005a,b,c].

Table 2. Influence of organic fertilization and mulching on Scots pine seedling height (cm)

Specification	Mulching		Mean
	S	C	
Białe Błota			
N_1	12.15	11.33	11.74
N_2	10.42	10.00	10.21
Mean	11.28	10.66	10.97
Lipnik			
N_1	10.63	10.30	10.46
N_2	6.66	8.13	7.39
Mean	8.64	9.21	8.92

N_1, N_2 - treated sewage sludge (⅔) + bark (⅓), treated sewage sludge (⅔) + sawdust (⅓), respectively;
S, C - mulching with litter and without mulching (control), respectively
Białe Błota: $LSD_{0.05}$: N_1, N_2 – 0.621; S, C – 0.421; interaction – n.s. not significant

Weight of seedlings

The fresh mass of the above-ground parts of Scots pine seedling was higher on the forest soil (2.35 g) as compared to that on the post-arable land (1.21 g). This mass of seedling was more differentiated on the post-arable land at Lipnik than on the forest soil at Białe Blota, and ranged from 0.7 to 2.2 g and from 2.21 to 2.41 g, respectively. Better results were obtained in the case of treatment N_1, but differences were significant only in the experiment on the post-arable land at Lipnik. In the case of the experiment at Białe Błota, all the differences were insignificant.

The roots of seedlings grown on the forest soil were characterized by higher fresh mass than those cultivated on the post-arable land (Table 4). The root fresh mass of seedling amounted, on average, 1.29 g at Białe Błota and 0.95 g at Lipnik, ranging from 1.11 to 1.61 g and from 0.86 to 1.1 g, respectively. The seedlings grown on treatments S (mulching with litter) were characterized by higher root mass in comparison to those on control plots (treatment C).

Table 3. Influence of organic fertilization and mulching on the fresh mass of theabove-ground parts of Scots pine seedling (g)

Specification	Mulching		Mean
	S	C	
Białe Błota			
N_1	2.41	2.38	2.39
N_2	2.21	2.40	2.30
Mean	2.31	2.39	2.35
Lipnik			
N_1	1.00	2.20	1.60
N_2	0.70	0.96	0.83
Mean	0.85	1.58	1.21

Explanations – see Table 2
Białe Błota: $LSD_{0.05}$: N_1, N_2 – n.s.; S, C – n.s.; interaction – n.s.

Table 4. Influence of organic fertilization and mulching on fresh mass of roots of a Scots pine seedling (g)

Specification	Mulching		Mean
	S	C	
Białe Błota			
N_1	1.61	1.22	1.41
N_2	1.23	1.11	1.17
Mean	1.42	1.16	1.29
Lipnik			
N_1	1.00	0.86	0.93
N_2	1.10	0.87	0.98
Mean	1.05	0.86	0.95

Explanations – see Table 2
Białe Błota: $LSD_{0.05}$: N_1, N_2 – 0.625; S, C - 322; interaction – n.s.

Occurrence of soil mites

Mites, especially saprophage Oribatida, are regarded as good bioindicators of the decomposition degree and biological properties of forest humus [Seniczak 1979]. Using the bioindicator properties of this group, it is possible to estimate, in general, the biological state of soil which can influence the growth of young trees. In addition, it is well known that oribatid mites can feed on ectomycorrhizal fungi [Schneider *et al*. 2005], and because of this they can stimulate the growth of these fungi and their expansion. Therefore, they can indirectly affect the seedlings of those species which need ectomycorrhizal fungi.

The density of mites on the investigated treatments varied from 0.69 to 11.02 thous. individuals $\cdot m^{-2}$ (Table 5). On control plots of the two regions of the study, the density was uniform and low. After mulching, the density increased 4-5 times at Białe Błota, but at Lipnik – even 10 times. These results indicate that the treatment of edaphon inoculation (called "zoo-melioration") was more effective at Lipnik than at Białe Błota. It seems that effect of this treatment can be connected with the differences in the temperature and rainfall conditions, and especially with the humidity during the vegetation period (Table 1).

On variants with mulching, saprophage Oribatida were distinctly predominant in gatherings of mites, but on control plots – other mites were more abundant . In the experiment at Białe Błota 28 species of oribatid mites were noted, and in that at Lipnik – there were 36 species of these mites. A very low number of species of oribatid mites (2-3) was noted on all the plots without mulching. This number was increased – as an effect of mulching – on the forest soil to 18 species (SN_1) and 24 species (SN_2), and on the post-arable ground – to 29 species and 30 species, respectively. On the base of statistical analysis, it was

concluded that the treatment of mulching influenced the general number of mites, the number of oribatid mites as well as their species diversity. On the other hand, organic fertilization (treated sewage sludge with bark or with sawdust) did not influence these indices.

Table 5. Abundance (*N* in 1000 individuals · m^{-2}) of mites, number of species (*S*), average number of species in sample (*s*) and Shannon index (*H*) for gatherings of Oribatida under different fertilization systems on the experimental sites at Białe Błota (B) and Lipnik (L) in cultivation of Scots pine

Index – group of mites	Object	Experimental treatment				Mulching effect (*p*)
		CN_1	SN_1	CN_2	SN_2	
N – Acari total	B	1.02	3.63(1)	0.97	5.42(1)	<0.001
	L	0.69	11.02	1.07	10.37	<0.001
N – Oribatida	B	0.08	1.40(1)	0.03	3.24(1)	<0.001
	L	0.05	7.81	0.05	6.97	<0.001
S – Oribatida	B	3	18	2	24	-
	L	2	29	2	30	-
s – Oribatida	B	0.08	0.87(1)	0.03	1.40(1)	<0.001
	L	0.03	2.55	0.05	2.62	<0.001
H – Oribatida	B	1.05	2.32	0.69	2.32	-
	L	0.64	2.15	0.64	2.36	-

(1) significant between B and L at $p = 0.05$

CONCLUSIONS

Scots pine seedlings grown on the forest soil at Białe Błota were characterized by increased height compared to those cultivated on the post-arable land at Lipnik. The best results, both on the forest soil as well as on the post-arable ground, were obtained in case of treatment SN_1 (plots mulched with litter and fertilized with treated sewage sludge (⅔) with bark admixture (⅓).

The higher was the rainfall amount during the vegetation period, the lower was the seasonal irrigation rate supplied to the Scots pine seedlings. Because of this the seasonal irrigation water rate applied at Białe Błota was higher than that at Lipnik.

Fresh mass of the above-ground parts of a Scots pine seedling was higher on the forest soil as compared to that on the post-arable land.

The seedlings grown on treatments mulched with litter were characterized by higher root mass in comparison to those on control plots (without mulching).

Mulching with litter influenced the total[?] number of mites, the number of oribatid mites as well as their species diversity. Organic fertilization (treated sewage sludge with bark or with sawdust) did not influence these indices.

REFERENCES

Aleksandrowicz-Trzcińska M. *Kolonizacja mikoryzowa i wzrost sosny zwyczajnej* (*Pinus sylvestris* L.) *w uprawie założonej z sadzonek w różnym stopniu zmikoryzowanych.* Acta Sci. Pol. Silv. Colendar. Rat. Ind. Lignar. 2004, 3, 5-15.

Babiński S., Białkiewicz F. *Deszczowanie szkółek. Szkółkarstwo leśne,* R. Sobczak (ed.). Wyd. Świat, Warszawa 1992, 130-191.

Bruchwald A. *Statystyka matematyczna dla leśników*. Wyd. SGGW, Warszawa 1997, 1-255.

Klimek A. *Wpływ zanieczyszczeń emitowanych przez wybrane zakłady przemysłowe na roztocze* (Acari) *glebowe młodników sosnowych, ze szczególnym uwzględnieniem mechowców* (Oribatida). Wyd. Uczeln. ATR, Rozprawy 99, Bydgoszcz 2000, 1-93.

Magurran A. E. *Ecological diversity and its measurement.* Chapman & Hall, London 1988, 1-179.

Niski A. *Nawożenie organiczne. Szkółkarstwo leśne,* Sobczak R.(ed.).Wyd. Świat, Warszawa 1992, 130-191.

Pierzgalski E., Tyszka J., Boczoń A., Wiśniewski S., Jeznach J., Żakowicz S. *Wytyczne nawadniania szkółek leśnych na powierzchniach otwartych.* Dyrekcja Generalna Lasów Państwowych, Warszawa 2002, 1-63.

Rolbiecki R., Rolbiecki S., Klimek A., Hilszczańska D. *Wpływ mikronawodnień i nawożenia organicznego na produkcję jednorocznych sadzonek sosny zwyczajnej (Pinus sylvestris L.) z udziałem zabiegu zoomelioracji.* Zesz. Probl. Post. Nauk Roln. 506, Warszawa 2005b, 335-343.

Rolbiecki R., Rolbiecki S., Klimek A., Hilszczańska D. *Wpływ mikronawodnień i nawożenia organicznego na produkcję jednorocznych sadzonek sosny zwyczajnej (Pinus sylvestris L.) na gruncie porolnym obiektu Kruszyn Krajeński z udziałem zabiegu zoomelioracji (Badania wstępne)*. Infrastruktura i Ekologia Terenów Wiejskich 4, 2005c, 131-143.

Rolbiecki R., Rolbiecki S., Klimek A., Hilszczańska D. *Wstępne wyniki badań wpływu deszczowania i mikronawodnień na produkcję jednorocznych sadzonek sosny zwyczajnej w warunkach zoomelioracji.* Rocz. AR Pozn. CCCLXV, Melior. Inż. Środ. 26, 2005a, 371-377.

Schneider K., Renker C., Maraun M. *Oribatid mite (Acari, Oribatida) feeding on ectomycorrhizal fungi.* Mycorrhiza 16, 2005, 67-72.

Seniczak S. *Fauna mechowców (Acari, Oribatei) jako indykator biologicznych właściwości próchnic leśnych.* Pr. Kom. Nauk. PTG V/37, 1979, 157-166.

Siuta J., Wasiak G. *Zasady wykorzystania osadów ściekowych na cele nieprzemysłowe.* Inżynieria Ekologiczna 3, 2001, 13-42.

Szujecki A*., Ekologiczne aspekty odtwarzania lasu na glebach porolnych*. Prace IBL ser. B, 27, Warszawa 1996, 47-55.

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