Teka Kom. Ochr. Kszt. Środ. Przyr. – OL PAN, 2008, 5 A, 31–37

SEEDLING RECRUITMENT OF COTTON-GRASS (*Eriophorum vaginatum* L.): IMPORTANCE OF CANOPY GAPS AND VEGETATION COVER

Wojciech Ejankowski

Department of Botany and Hydrobiology, The John Paul II Catholic University of Lublin,
C.K. Norwida str. 4, 20–061 Lublin, wejan@kul.lublin.pl

Summary. Cotton-grass (*Eriophorum vaginatum* L.) occurs commonly in natural, as well as anthropogenically altered peatlands. It is peat-forming species participating in revegetation and supporting restoration of mires. In this study influence of disturbance and vegetation cover on seedling recruitment of *E. vaginatum* was examined in two peat bogs in the region Polesie Lubelskie (Eastern Poland). Number of seedlings was lower in forest bog than open bog due to low production of seeds, in spite of similar density of tussocks in both sites. Number of seedlings was the highest in experimentally disturbed sites, but gap formation stimulated seedling emergence only in open bog. Hydrological alterations in peatlands that lead to development of tree stands can affect negatively recruitment of typical peat bog species by limitation of fecundity of plants.

Key words: cotton-grass, disturbance, *Eriophorum vaginatum*, fecundity, peat bogs, seedling emergence

INTRODUCTION

Drainage in peatlands influences species composition due to altered hydrologic conditions, soil aeration and increased nutrient availability. Typical light-demanding peatland species disappear, with development of shrubs and trees after desiccation [Laine *et al*. 1995, Frankl and Schmeidl 2000].

Cotton-grass (*Eriophorum vaginatum* L.) is one of the most common species of family *Cyperaceae* in ombrotrophic peatlands in circumboreal regions. It occurs not only in natural mires, but also in strongly altered bogs and even in anthropogenic habitats, as grazing areas and abandoned fields after peat mining [Wein and MacLean 1973, Matuszkiewicz 2001, Lavoie *et al*. 2005].

Dynamics of *E. vaginatum* cover is affected by hydrological conditions. Cotton-grass is promoted in well-hydrated sites [Lanta *et al*. 2004, Lavoie *et al*.

2005]. It can achieve success also in forest bogs because seeds of this plant can germinate under less favourable moisture conditions than other typical bog species.

There is abundant evidence that this species can improve moisture conditions for other plants in strongly disturbed sites, and may be used for restoration of peat-forming vegetation in bogs after economic use. Hence, development of *E. vaginatum* should be promoted in many restored peatlands [Buttler *et al*. 1996, Lavoie *et al*. 2003].

This study had the aim to examine the effects of canopy gaps and vegetation cover on seedling emergence of cotton-grass, and to understand how development of woody vegetation in peat bogs can affect seedling recruitment of *E. vaginatum* – the typical peat bog species.

MATERIAL AND METHODS

The study was carried out in two peatlands near the town Włodawa in the region Polesie Lubelskie in Eastern Poland [Kondracki 1998]. Two contrasting vegetation cover conditions were chosen in this study. Małe Bog is covered mainly by open bog vegetation with sparsely distributed trees and shrubs, while Żłobek is predominated by swampy forests comprised of shade-producing trees – Scots pine (*Pinus sylvestris* L.) and pubescent birch (*Betula pubescens* Ehrh.).

Experimental plots consisted of linearly arranged, alternatingly situated disturbed and undisturbed squares (0.25 m^2) with 0.5 m spacing between them. A total 36 squares were used in the study. Vegetation and 5 cm of soil were removed in each disturbed site. Experimental gaps were created in April 2006, and seedling establishment was followed every month during two seasons – 2006 and 2007 – between May and November. Water table level was measured using piezometers, between May and November 2006, and between April and November 2007. Seedlings were collected and cleaned in laboratory. *Eriophorum vaginatum* was identified on the ground of nuts and utricles [Kowal 1958]. Additionally, percentage cover and density of tussocks, number of infructescences and production of nuts of cotton-grass was counted in 40 random squares of 0.25 m^2.

Non-parametric test was used or data were log-transformed if they did not fit the assumptions of parametric analysis [Sokal and Rohlf 1995]. Calculations were performed with Statistica ver. 8.0.

RESULTS

Water level was significantly higher in Małe Bog than in Żłobek (Wilcoxon test, $Z = 3.02$, $P < 0.01$). Level of water table was on average 14 cm above ground level in Małe Bog and 8.6 cm under ground in Żłobek. Experimental sites were

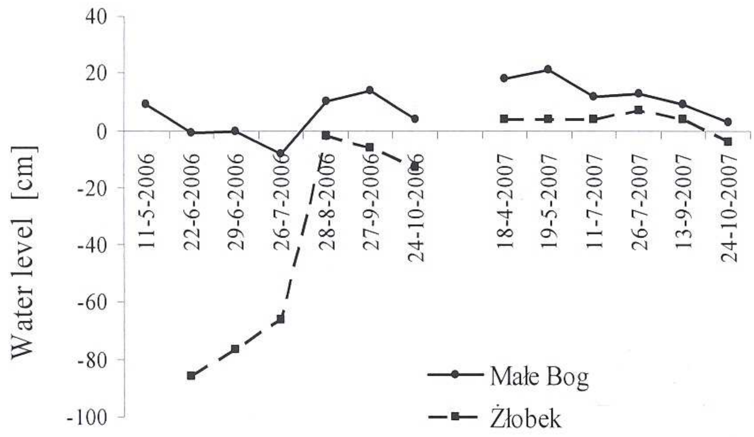

Fig. 1. Seasonal changes of water level in study sites in Małe Bog and Żłobek in 2006 and 2007

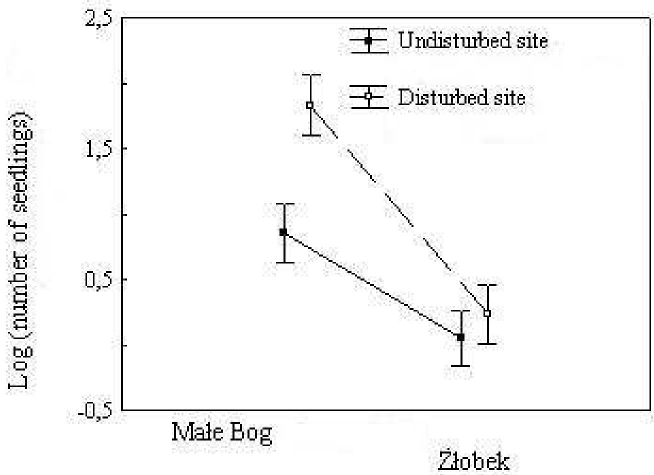

Fig. 2. Number of seedlings of *Eriophorum vaginatum* in disturbed and undisturbed sites in Małe Bog and Żłobek

Table 1. F-values of ANOVA of the influence of type of peat bog and disturbance, the effect of interaction between them on the number of seedlings, and effect of peat bog on density of tussocks, infructescences and production of nuts in cotton-grass (*Eriophorum vaginatum*)

Effect	Peat bog	Disturbance	Peat bog × Disturbance
Seedlings	119.01***	27.33***	12.94**
Infructescences	67.0***	–	–
Nuts	81.9***	–	–
Tussocks	0.7 n.s.	–	–

Data were log-transformed ($\log_{10}(x+1)$) prior to analysis. Signatures: **P < 0.01, ***P < 0.001, n.s. – not significant

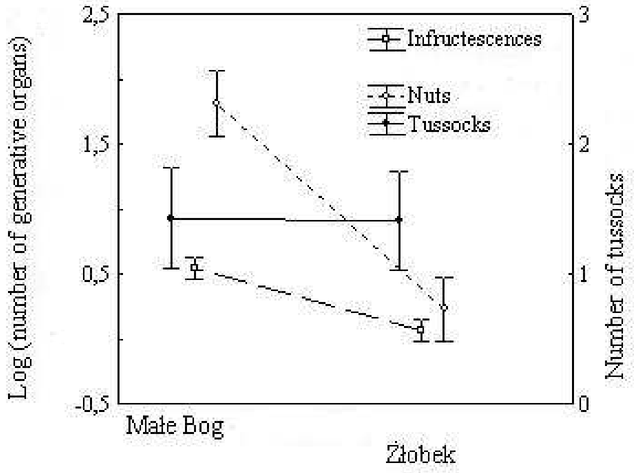

Fig. 3. Density of tussocks and infructescences and production of nuts in cotton-grass (*Eriophorum vaginatum*) in study sites in Małe Bog and Żłobek

inundated in open bog, with the exception of June–July 2006. In forest bog the water level was under ground in 2006 and above ground in 2007, except for October, when the water table was near the ground level (Fig. 1).

The number of seedlings of *E. vaginatum* was related to the type of peat bog (Tab. 1). Cotton-grass was more abundant in Małe Bog (153.9 seedlings per m^2) than in Żłobek (3.8 seedlings per m^2). More seedlings were found in experimentally disturbed sites (133.6 m^{-2}) than in control sites (21.9 m^{-2}). The effect of interaction between type of bog and disturbance indicates that seedling establishment in patches devoid of vegetation cover was accelerated in Małe Bog, whereas emergence of cotton-grass in disturbed sites strongly decreased in Żłobek (Fig. 2). The effect of canopy gaps on seedling emergence of *E. vaginatum* was revealed only for open bog. No significant difference between the number of seedlings in disturbed and undisturbed sites was found in Żłobek ($F = 1.97$, $P > 0.05$).

Seed rain was significantly higher in Małe Bog (400 nuts per m^2) than in Żłobek (13.4 nuts per m^2). Similarly, production of infructescences was higher in open bog than in forest bog, at 0.9 and 11.4 per m^2, respectively (Tab. 1, Fig. 3). Percentage cover of *E. vaginatum* was, on average, 35% in forest bog and 50% in open bog, although density of tussocks was similar in Żłobek and Małe Bog, at 5.6 m^{-2} and 5.7 m^{-2}, respectively (Fig. 3).

DISCUSSION

Seasonal changes of water level in Małe Bog and Żłobek reflected meteorological conditions in 2006–2007. Low water level in peatlands in 2006 was influenced by low precipitation, especially in May–July 2006. Water table level in 2007 was high owing to relatively wet year [www.imgw.pl]. Hydrological conditions in Małe Bog and Żłobek were significantly different. The results of this study confirmed that low level of water table in bogs enables development of closed cover of trees [Laine *et al*. 1995], and that abundance of cotton-grass is related to hydration of bog [Lavoie *et al*. 2005].

The number of seedlings of *E. vaginatum* in Małe Bog and Żłobek was affected by current vegetation cover, despite no significant correlation between the number of infructescences and the number of emerging seedlings. A similar situation was found in vacuum-mined peatland in Québec. As suggested by Lavoie *et al*. [2005], longer time series may be needed to detect the significant correlation. In this study, shading induced by trees could affect low fecundity of cotton-grass. Indeed, production of mature seeds in *E. vaginatum* in tundra was strongly restricted in the shade treatment [Molau and Shaver 1997]. In effect of low seed production, seedling emergence was much lower in forest bog than in open bog community. The density of cotton-grass in the experimental sites in 2006 was close to fecundity (Fig. 2–3). The importance of seed rain in seedling recruitment is often emphasized. Plant colonization in disturbed sites is related to immigration potential of colonizing species from the surroundings [Beckage *et al*. 2000, Campbell *et al*. 2003].

The influence of seedling recruitment on vegetation cover seems to be scarce. In spite of considerable difference in seedling numbers in the examined bogs, the density of tussocks was similar. However, seedling recruitment can affect the abundance of cotton-grass after disturbance. Mortality of *E. vaginatum* in disturbed tussock tundra is very low during the first years after germination [Gartner *et al*. 1983], thus establishment from seeds could play an important role in the dynamics of cotton-grass cover in canopy gaps. In fact, cotton-grass has an important role in overgrowing of bare peat in the region of Polesie Lubelskie. It is the main vascular plant species in the final stage vegetation of terrestrialised nutrient poor peat pits [Urban 2007].

Seedling emergence and development of vegetation is determined by initial species pool and can be limited in harsh environmental conditions [Campbell *et al*. 2003, Cooper *et al*. 2004]. Germination of seeds is often hampered by dense vegetation canopy and deep litter layer [Grubb 1977, Overbeck *et al*. 2003]. Gaps are often considered as „safe sites" for seedling recruitment [Harper 1977]. Disturbance in this study was simulated by the activity of animals and peat mining. Seedlings of cotton-grass were more numerous on bare peat, whereas development of seeds on vegetated surface was sparse. The study shows that dense vegetation comprised of mosses of genus *Sphagnum* hampers seedling establishment of *E. vaginatum*.

Many characteristics facilitate the establishment and survival of cotton-grass in bare peat, even if the bog has been drained. *Eriophorum vaginatum* has the maximum germination rates in high temperatures (25–30°C) and seed germination is stimulated in light conditions, which is common in summer above peat surface after strong disturbance [Wein and MacLean 1973]. Numerous seeds are produced each year and have a high ability to disperse by wind because of hairy nuts [Campbell *et al*. 2003]. Finally, cotton-grass tolerates periods of droughts [Wein 1973].

Nevertheless, the effect of strong disturbance in terms of removal of plants and upper soil layer does not improve conditions for seedling emergence in afforested peat bog. This suggests that the importance of gaps as niches for regeneration of cotton-grass may be related to the type of vegetation. Dense understory cover can neutralize recruitment opportunities even if the canopy has been disturbed [Beckage *et al*. 2000].

On the other hand, incommensurably low number of seedlings on bare peat in forest bog could be caused by insufficient moisture conditions. The season of 2006 was especially dry, which could affect negatively the germination of seeds in experimental gaps. Only in open bog the vegetation cover restricted recruitment from seeds and the effect of dryness was unnoticeable. However, the focal species is highly tolerant to low soil moisture and can germinate in relatively dry sites [Lavoie *et al*. 2005]. In 2007 the experimental sites were inundated, so seedlings recruitment of cotton-grass was generally sparse.

CONCLUSION

Seedling establishment of *Eriophorum vaginatum* is enhanced in well-hydrated peat bogs owing to high production of seeds. Abundance and fecundity of cotton-grass are higher in open bog with high level of water table than in forest bog. Disturbance stimulates the emergence of cotton-grass, but the effect of canopy gaps was found only in open peat bog. Expansion of forest vegetation in peatlands due to desiccation can affect negatively seedling recruitment of *E. vaginatum*.

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REKRUTACJA SIEWEK WEŁNIANKI POCHWOWATEJ (*Eriophorum vaginatum* L.): ZNACZENIE ZABURZEŃ I POKRYWY ROŚLINNEJ

Streszczenie. Wełnianka pochwowata (*Eriophorum vaginatum* L.) występuje pospolicie na torfowiskach wysokich, naturalnych, jak i przekształconych przez człowieka. Jest gatunkiem torfotwórczym uczestniczącym w regeneracji roślinności i wspomagającym procesy renaturalizacji torfowisk. W pracy badano wpływ typu roślinności oraz luk w pokrywie roślinnej na rekrutację siewek *E. vaginatum* na dwóch torfowiskach Polesia Lubelskiego (Żłobek, Bagno Małe). Stwierdzono, że liczebność siewek była niższa na torfowisku leśnym niż nieleśnym z powodu małej produkcji nasion, pomimo podobnego zagęszczenia kęp wełnianki na obu torfowiskach. Najwięcej siewek pojawiło się na zaburzonych powierzchniach eksperymentalnych, ale tworzenie luk stymulowało pojawianie się siewek tylko na torfowisku nieleśnym. Zmiany hydrologiczne torfowisk prowadzące do rozwoju drzewostanów mogą wpływać na rekrutację siewek gatunków typowo torfowiskowych przez ograniczenie płodności roślin.

Słowa kluczowe: *Eriophorum vaginatum*, płodność, rekrutacja siewek, torfowiska, wełnianka pochwowata, zaburzenia