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Species dependent root decomposition in rewetted fen soils

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Abstract

Experiments in a rewetted fen show large differences in root decomposition rates among *Phragmites australis*, *Carex paniculata*, and *Carex riparia*. With equal water table fluctuations no differences in decomposition were observed in the two rewetting variants, with temporary standing and constantly flowing water. The marked differences among species are therefore attributed to differences in plant material quality, though C/N ratio is shown not to be of main influence. Based on low decomposition rates, *Phragmites australis* proved the species most suitable for (renewed) peat accumulation under sufficient wet conditions.

Introduction

Peat accumulation results generally from slow decomposition rather than by high net primary production (Clymo, 1983). Decomposition rates in natural peatlands are low because of high water tables leading to a shortage of oxygen (Bartsch and Moore, 1985). In drained peatlands the low water table results in a higher microbial activity and consequently in large peat decomposition losses. This is associated with large emissions of nutrients and greenhouse gases (CO_2, CH_4, N_2O).

The research project ‘Management of fen ecosystems’ investigates the possibilities of minimizing peat losses and initiating new peat accumulation by rewetting of drained fens and planting fen typical species. A central question in peatland restoration is the quantification of peat losses that occur before and during rewetting. Methods employed to quantify decomposition losses include measuring soil respiration, changes in C/N ratio of the peat, and changes in weight of an introduced substrate. Measuring the weight losses of natural or artificial substrates placed in the peat over a period of time, is the most common method of determining decomposition rates in peatlands (Bartsch and Moore, 1985; Verhoeven and Arts, 1992). Often cellulose or cotton strips are used as standard substrates when comparing decomposition rates in various wetland types (Maltby et al., 1996). Natural below ground plant materials are hardly used for this purpose. The cellulose material, however, only provides the decomposers with C (Szumigalski and Bayley, 1996), whereas natural materials also provide additional nutrients. This paper reports on decomposition studies on root material of various fen typical plant species to determine their suitability for renewed peat accumulation.

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Material and methods

The ‘Friedlaender Große Wiese’ is a 9300 ha large drained fenland in northeastern Germany (53°35′ N, 13°45′ E). About 15 ha of this formerly intensively used grassland were rewetted starting 1996, using two alternative strategies: ‘border irrigation’ (flowing water) and ‘temporary inundation’(temporary standing water) (Hartmann et al., 1999). The decomposition of fresh root material of *Phragmites australis* (CAV.) TRIN. ex STEUD., *Carex paniculata* L. and *Carex riparia* CURTIS was studied in field experiments under the two rewetting variants using the litter bag technique. Each bag contained 5 g of fresh root material. The dry weight equivalent of the root material was

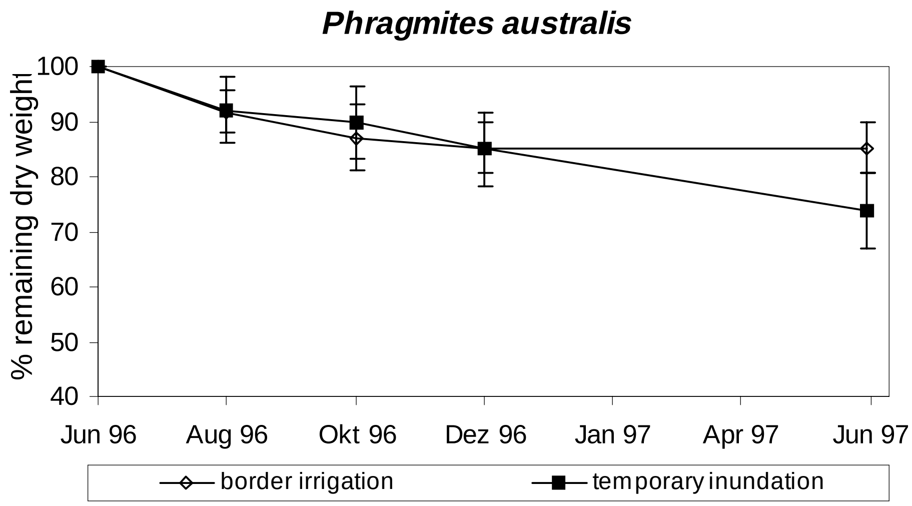

Figure 1. Decomposition of *Phragmites australis* root material after 2, 4, 6 and 12 months in the rewetting variants: 'border irrigation' and 'temporary inundation'. Mean values with standard deviations, *n* = 10.

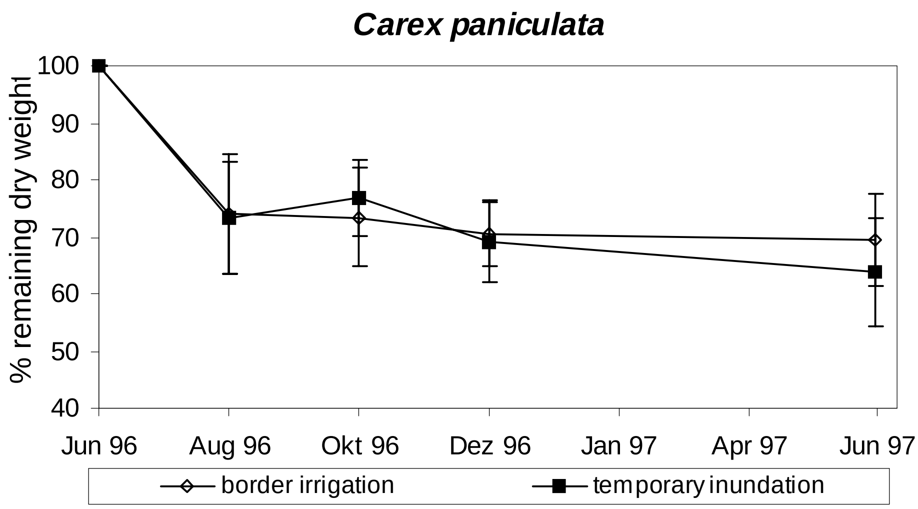

Figure 2. Decomposition of *Carex paniculata* root material after 2, 4, 6 and 12 months in the rewetting variants: 'border irrigation' and 'temporary inundation'. Mean values with standard deviation, *n* = 10.

determined in 10 parallels prior to burying. The litter bags were buried 10 cm below surface and remained there for 2, 4, 6 or 12 months. Losses in the dry weight of the roots were interpreted as decomposition. The chemical composition of the roots was determined before and after exposition in the field. The material was oven dried (40 °C) and ground through a 0,120 mm mesh in a rotor-mill. Total N and C was estimated using a CHN analyzer (HERAEUS, Vario el), and α-cellulose was determined with the sodium chlorite procedure (cf. Allen, 1989).

Results

The results show marked differences between the investigated plant species (Figure 1–3). The slowest decomposition rate was observed in the roots of *P. australis* (Figure 1), followed by *C. paniculata* (Figure 2), and *C. riparia* roots with the highest rate of decay (Figure 3). The fastest decomposition of roots took place in the first two months. The rewetting variants 'temporary inundation' and 'border irrigation', did not show large differences, probably because of largely similar water level fluctuations.

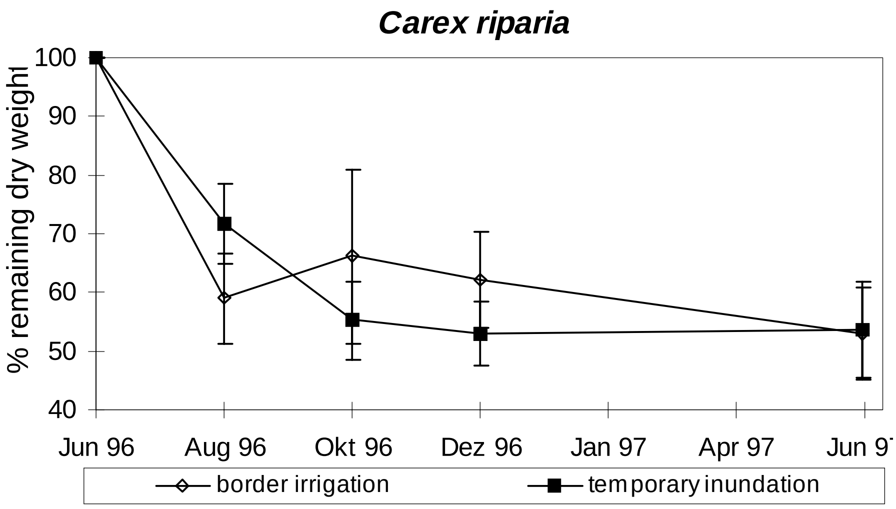

Figure 3. Decomposition of *Carex riparia* root material after 2, 4, 6 and 12 months in the rewetting variants: 'border irrigation' and 'temporary inundation'. Mean values with standard deviations, $n = 10$.

The cellulose content in roots of *P. australis* and *C. paniculata* decreases very slowly (Figure 4, 5). Roots of *C. riparia* lost a large part of their cellulose in the first two months after burying. *C. riparia* had the highest initial root cellulose content of all investigated species, and also showed the highest decomposition rates.

No obvious trends could be observed with respect to C and N content of the roots (Table 1). In the first two months the N content of *C. riparia* (irrigation), *P. australis* (inundation) and *C. paniculata* (inundation) decreased, but afterwards markedly increased. The N content of *C. riparia* (inundation) and *P. australis* (inundation) roots increased during the first 6 months (until December). In the second half of the experiment (December 1996 – June 1997) an increase in the N content of *C. riparia* and *C. paniculata* roots was found, independent of the rewetting variant. There was no apparent relationship between the initial N content of the roots and the decomposition rate. Roots with the lowest initial N content (*C. riparia)* showed the highest decomposition rates. *P. australis* had the lowest losses in dry weight in spite of high N contents.

Discussion

The differences in root decomposition between the rewetting variants 'temporary inundation' and 'border irrigation' are smaller than expected. This may be attributed to largely similar water level fluctuations in both variants, that seem to over-rule the effects of water flow.

Closer examination of the root substances including cellulose reveals larger differences among the investigated plant species than between the rewetting variants. Apparently the quality of the roots is very important for the differences in decomposition between plant species. Especially the amount of cellulose associated with lignin may be important in this respect (Coulson and Butterfield, 1978; Benner et al., 1985), as lignocellulosic plant matter is very resistant to decomposition in anoxic environments (Benner et al., 1984). Roots of *C. riparia*, that had the highest cellulose content of all investigated species, however, also showed highest cellulose losses and overall decomposition rates. Probably its cellulose is not associated with lignin. Overall the fastest decomposition of roots took place in the first two months, a result of leaching out of the soluble fraction, such as carbohydrates (Polunin, 1982; Hietz, 1992). Many authors have stressed the importance of the C/N ratio in the mineralization of biological materials (Clymo, 1983; McKane et al., 1997; Cotrufo et al., 1994). According to Tupacz and Day (1990) substrates with a C/N ratio ≤ 30 are easily decomposed. In case of higher C/N ratios a shortage of Nitrogen leads to retarded decomposition. The investigated roots had C/N ratios between 45 and 48. Decay can be expected to lead to increasing C/N ratios because of a decrease of N content (Gisi, 1990).

In decomposition experiments with above ground material trends in the N content through time of the

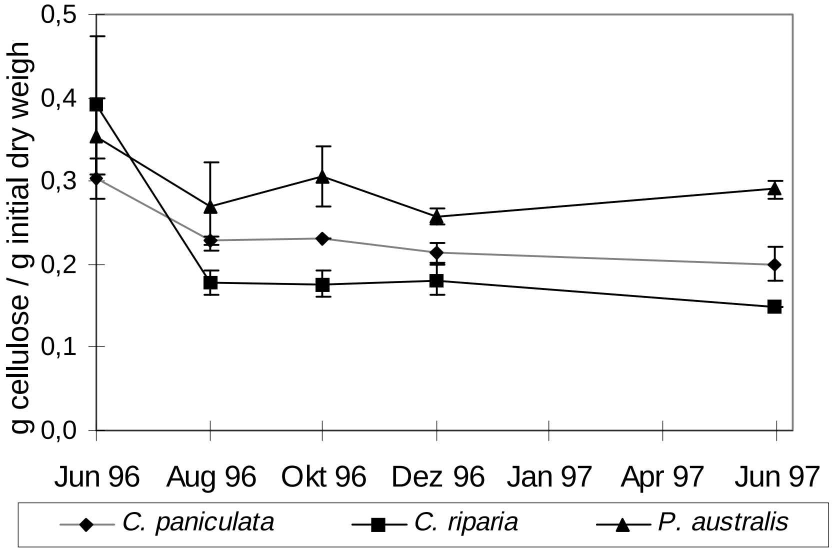

Figure 4. Loss of cellulose in *Carex paniculata*, *Carex riparia* and *Phragmites australis* roots June 1996 – June 1997, investigation site 'border irrigation'.

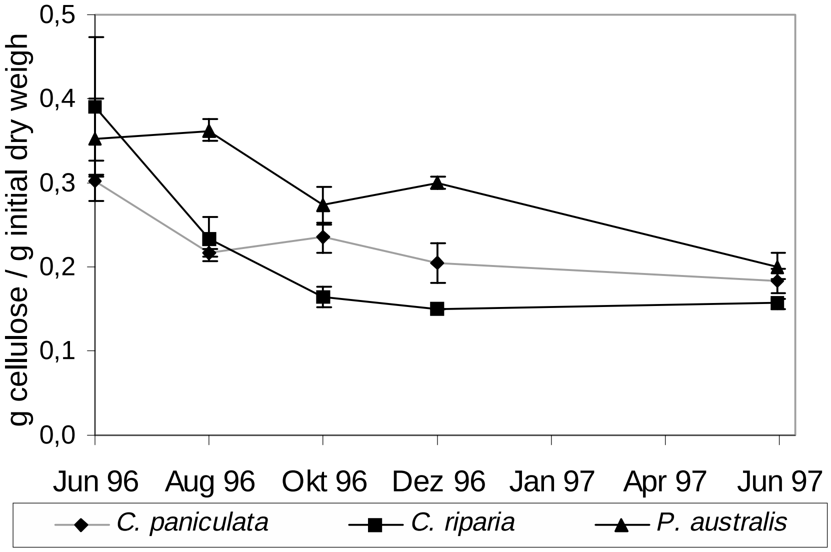

Figure 5. Loss of cellulose in *Carex paniculata*, *Carex riparia* and *Phragmites australis* roots June 1996 – June 1997, investigation site 'temporary inundation'.

material are apparent. After an initial strong decrease of the N content, attributed to leaching, there is an increase, which is explained by colonization of the litter by microorganisms (Mason and Bryant, 1975; Polunin, 1984; Verhoeven and Arts, 1992). Hietz (1992) does not describe the initial decrease, but also finds an increase in N content before its decrease due to decomposition. Such apparent trends were not observed in the N content of the below ground root material studied here. Similar observations were reported by Hackney and De La Cruz (1980) for roots and rhizomes of *Spartina cynosuroides* and *Juncus roemerianus.* Klimaneck (1990) shows that the degree and intensity of root decomposition primarily depend on the ratio of stable and easily mineralizable components. Criteria such as N content and C/N ratio are of minor importance for the C-turnover (Klimaneck and Schulz, 1997). Our experiments support this view.

Phragmites australis roots showed the lowest overall and cellulose decomposition of the investigated

Table 1. Changes in C and N content of roots, June 1996 – June 1997. Mean values with standard deviations in brackets, $n = 5$

		N%	C&
P. australis	Jun 96	0.94 (0,01)	44.7 (0.00)
border irrigation	Aug 96	0.92 (0.08)	48.3 (0.65)
	Oct 96	0.90 (0.00)	49.0 (0.04)
	Dec 96	1.01 (0.05)	49.1 (0.15)
	Jun 97	0.93 (0.02)	46.5 (0.32)
P. australis	Jun 96	0.94 (0.01)	44.7 (0.00)
temporary inundation	Aug 96	1.01 (0.05)	47.8 (0.38)
	Oct 96	1.19 (0.02)	48.2 (0.07)
	Dec 96	1.03 (0.17)	48.6 (0.33)
	Jun 97	1.08 (0.01)	46.5 (0.66)
C. riparia	Jun 96	0.92 (0.01)	44.3 (0.21)
border irrigation	Aug 96	0.66 (0.00)	47.6 (0.01)
	Oct 96	1.11 (0.07)	47.8 (0.13)
	Dec 96	1.03 (0.07)	47.6 (0.41)
	Jun 97	1.21 (0.14)	46.5 (0.39)
C. riparia	Jun 96	0.92 (0.01)	44.3 (0.21)
temporary inundation	Aug 96	1.09 (0.08)	47.3 (0.24)
	Oct 96	1.30 (0.10)	47.7 (0.19)
	Dec 96	1.17 (0.10)	47.9 (0.05)
	Jun 97	1.46 (0.05)	45.9 (0.08)
C. paniculata	Jun 96	1.01 (0.02)	46.0 (0.02)
border irrigation	Aug 96	0.90 (0.00)	47.9 (0.64)
	Oct 96	0.76 (0.01)	48.3 (0.04)
	Dec 96	0.60 (0.03)	48.5 (0.10)
	Jun 97	0.82 (0.05)	46.3 (0.13)
C. paniculata	Jun 96	1.01 (0.02)	46.0 (0.02)
temporary inundation	Aug 96	0.76 (0.01)	48.3 (0.40)
	Oct 96	0.81 (0.04)	48.5 (0.11)
	Dec 96	0.77 (0.02)	46.7 (0.18)
	Jun 97	0.90 (0.07)	46.3 (0.11)

plant species. Based on this, this species is best suitable for (renewed) peat accumulation under sufficient wet conditions.

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