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Nutrient retention by differently managed vegetation of buffer zones

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Abstract

Shoots growth and nutrient concentration of differently vegetated buffer zones (BZ) were studied in south-western Finland with clay soils. Aboveground plant biomasses differed greatly among each of the six vegetation types with different age and harvesting practice. The concentration of P_{AAAc} in soil surface increased with natural vegetation with no harvest. The preliminary results for the BZ plots emphasized the role of vegetation and grazing in an additional nutrient loading.

1. Introduction

Vegetated buffer zones (BZ) are found to be very effective in removing total phosphorus (TP) and sediment losses from agricultural runoff. The mean percentage TP retention ranged between 27 and 97% in BZs in Nordic countries. Whereas the retention of dissolved reactive phosphorus (DRP) varied from 14% to negative which was probably caused by DRP leaching from the soil surface and plant material (Uusi-Kämppä *et al*. 2000). BZ length was found to have the most significant effect on P and sediment removal, while vegetation characteristics has only secondary influences (Abu-Zreig *et al*. 2003, Hook 2003). On the other hand, Uusi-Kämppä (2005) reported that natural vegetated and grass buffer strips reduced particulate P (PP) load by 55 and 47%, respectively. The objective of this study was to evaluate both the influence of vegetation on nutrient retention and nutrient removal efficiency in different vegetated and managed BZs.

2. Materials and methods

The study site was located in an agricultural region at Jokioinen, in south-western Finland. The soil was classified as Typic Cryaquept/Vertic Cambisol consisting of clay content over 50% with pH (H_2O) of the surface soil ranging between 5.4 and 5.9. The study was performed in the next six following BZs:

- old BZ with natural vegetation, scrubs and hardwood trees (No. 3),
- old BZ with grass species which are annually harvested and removed (No. 4),
- young BZ with grass species which are grazed by cattle (No. 5),
- old BZ with grass species which are grazed by cattle (No. 7),
- young BZ with grass species which are annually harvested and removed (No. 8),
- old BZ with natural grass species which are not harvested (No. 9).

These differently managed vegetation plots were referred later as no. 3, no. 4, no. 5, no. 7, no. 8 and no. 9, respectively. The first three plots were located in an area of long-term BZ experimental field with widths up to 18 m at an average slope of 16% (see e.g. Uusi-Kämppä 2005). The latter three plots were situated adjacent to the experimental field, and acted as the reference material in relation to the process of ageing and management practices.

Soil samples were collected at three different depths (0–2, 2−5, 5−10 cm). All soil samples were oven-dried, ground and sieved for P analysis. The agronomic soil P test (P_{AAAc}) was conducted using an acid ammonium acetate -solution for samples collected in October (10.10.05). Plant biomasses were sampled in May (02.05.05), June (28.06.05), August (09.08.05), October (10.10.05) and November (23.11.05) by clipping vegetation at the ground surface in five areas of 50 cm x 50 cm per each plot. Plant materials were weighed before and after oven-dried at 60°C, finely ground and analyzed for total C, N and P. Tukey´s procedure was used to determine the differences between BZs within each sampling date at significance level α = 0,05. Total P was determined colorimetrically using procedure for acid extracts of dry ashed samples. Total C and N were analyzed using by dry combustion with a Leco CHN 1000 analyzer.

3. Results and discussion

Aboveground plant biomasses differed greatly among each of the six vegetation types (Table 1). Total fresh biomasses varied from an average minimum of 0.7 kg m^{-2} at the sites No. 5 and 7 to an average maximum of 1.4 kg m^{-2} at the site No. 3 and 9.

Table 1. Fresh mass yields (g 0.25 m^{-2}) (mean ± SE). Means with the same letter are not significantly different.

Sampling date	*No. 3*	*No. 4*	*No. 5*	*No. 7*	*No. 8*	*No. 9*
May 02	71 ± 7^{a}	48 ± 7^{ba}	36 ± 5^{b}	32 ± 10^{b}	78 ± 9^{a}	58 ± 8^{ba}
June 28	323 ± 22^{cb}	283 ± 53^{cb}	216 ± 80^{c}	161 ± 51^{c}	463 ± 39^{b}	761 ± 30^{a}
August 09	473 ± 55^{a}	313 ± 37^{ba}	162 ± 46^{bc}	125 ± 29^{c}	313 ± 46^{ba}	358 ± 28^{a}
October 10	294 ± 64^{ba}	141 ± 9^{c}	138 ± 32^{c}	179 ± 24^{bc}	81 ± 10^{c}	363 ± 32^{a}
November 23	346 ± 19^{a}	95 ± 22^{c}	299 ± 48^{ba}	187 ± 41^{bc}	107 ± 15^{c}	413 ± 40^{a}

Dry mass proportion of the plant fresh biomasses was the highest (49−89%) later in the spring and the lowest (19−26%) later in the autumn (Table 2).

Table 2. Dry mass yields (g 0.25 m^{-2}) (mean ± SE).

Sampling date	*No. 3*	*No. 4*	*No. 5*	*No. 7*	*No. 8*	*No. 9*
May 02	63 ± 6^{a}	27 ± 4^{bc}	21 ± 3^{c}	16 ± 5^{c}	45 ± 4^{ba}	52 ± 7^{a}
June 28	92 ± 14^{bc}	74 ± 11^{c}	52 ± 17^{c}	45 ± 12^{c}	130 ± 9^{ba}	152 ± 9^{a}
August 09	148 ± 4^{a}	137 ± 14^{a}	59 ± 12^{b}	53 ± 11^{b}	157 ± 16^{a}	153 ± 10^{a}
October 10	121 ± 15^{a}	42 ± 3^{b}	62 ± 15^{b}	52 ± 6^{b}	36 ± 4^{b}	153 ± 13^{a}
November 23	91 ± 6^{a}	20 ± 4^{c}	56 ± 9^{b}	41 ± 8^{cb}	22 ± 4^{c}	97 ± 7^{a}

At the end of the growing season, the C content of plants was significantly greatest over the treatments (Table 3). The same was not noticed in respect to N % (data not shown). An average N content varied from 1.7% (No. 7) to 1.1% (No. 9).

Table 3. C–% of the dry masses (mean ± SE).

Sampling date	*No. 3*	*No. 4*	*No. 5*	*No. 7*	*No. 8*	*No. 9*
May 02	42.8 ± 0.3^{a}	43.8 ± 0.4^{a}	41.2 ± 0.3^{a}	41.9 ± 1.4^{a}	42.5 ± 0.4^{a}	43.4 ± 0.3^{a}
June 28	43.5 ± 0.1^{ba}	43.7 ± 0.2^{ba}	43.3 ± 0.3^{b}	43.9 ± 0.2^{ba}	44.2 ± 0.2^{a}	43.3 ± 0.2^{ba}
August 09	42.7 ± 0.1^{bc}	43.7 ± 0.2^{ba}	42.6 ± 0.2^{c}	43.8 ± 0.2^{a}	43.6 ± 0.3^{bac}	43.3 ± 0.3^{bac}
October 10	43.3 ± 0.3^{a}	43.2 ± 0.3^{a}	43.3 ± 0.2^{a}	43.1 ± 0.3^{a}	43.4 ± 0.3^{a}	43.2 ± 0.2^{a}
November 23	46.5 ± 0.2^{bc}	46.6 ± 0.3^{ba}	45.7 ± 0.1^{c}	45.9 ± 0.2^{bc}	46.0 ± 0.2^{bc}	47.5 ± 0.2^{a}

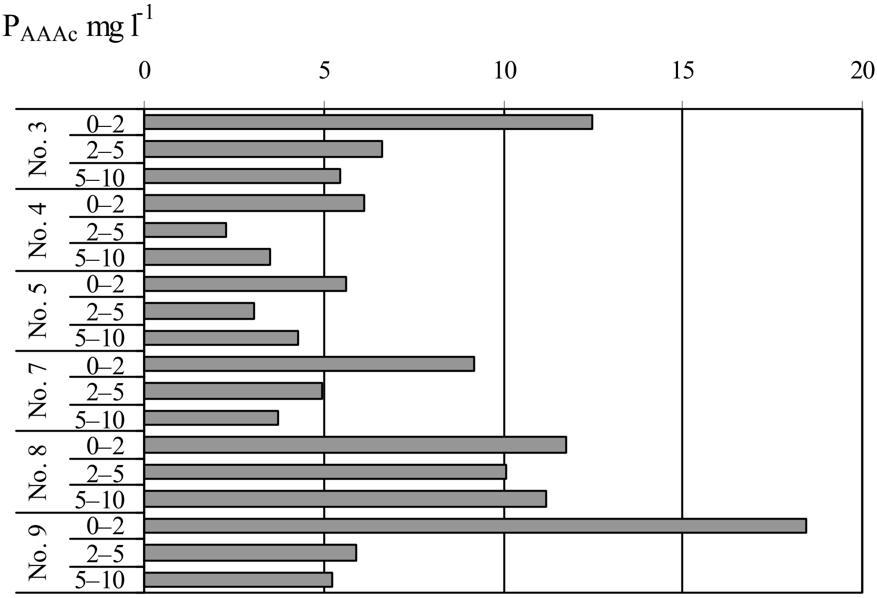

Figure 1. The concentrations of acid ammonium acetate -soluble phosphorus (P_{AAAc}) in relation to the different BZs and soil layers (0–2, 2–5 and 5–10 cm).

In conformity with Uusi-Kämppä (2005), at the depth of 0−2 cm the soil P_{AAAc} – concentration was higher in the plot with natural vegetation (No. 3) than in the plot with annually harvested grass species (No. 4). Relative large increase in P_{AAAc} was most likely as a result of plant materials which were not harvested and removed. In the upper part of the soil surface, the order of the rates of decrease in P_{AAAc} – concentrations was No. 9 > No. 3 > No. 8 > No. 7 > No. 4 > No. 5 (Figure 1). At the depth of 2−10 cm, the differences between plots were minor (not so distinct). Results show that grazing continued for several years produce an additional P – load to the surface soil.

4. Conclusions

The preliminary results for the BZ plots emphasized the role of vegetation and grazing in an additional nutrient loading. Temporal dynamic of the soil P status will be analysed in future.

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