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The effect of native and introduced biofuel crops on the composition of soil biota communities

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ABSTRACT

Biofuel crops are an accepted alternative to fossil fuels, but little is known about the ecological impact of their production. The aim of this contribution is to study the effect of native (*Salix viminalis* and *Phalaris arundinacea*) and introduced (*Helianthus tuberosus*, *Reynoutria sachalinensis* and *Silphium perfoliatum*) biofuel crop plantations on the soil biota in comparison with cultural meadow vegetation used as control. The study was performed as part of a split plot field experiment of the Crop Research Institute in the city of Chomutov (Czech Republic). The composition of the soil meso- and macrofauna community, composition of the cultivable fraction of the soil fungal community, cellulose decomposition (using litter bags), microbial biomass, basal soil respiration and PLFA composition (incl. F/B ratio) were studied in each site. The C:N ratio and content of polyphenols differed among plant species, but these results could not be considered significant between introduced and native plant species. Abundance of the soil meso- and macrofauna was higher in field sites planted with *S. viminalis* and *P. arundinacea* than those planted with *S. perfoliatum*, *H. tuberosus* and *R. sachalinensis*. RDA and Monte Carlo Permutation Test showed that the composition of the faunal community differed significantly between various native and introduced plants. Significantly different basal soil respiration was found in sites planted with various energy crops; however, this difference was not significant between native and introduced species. Microbial biomass carbon and cellulose decomposition did not exhibit any statistical differences among the biofuel crops. The largest statistically significant difference we found was in the content of actinobacterial and

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bacterial (bacteria, G+ bacteria and G− bacteria) PLFA in sites overgrown by *P. arundinacea* compared to introduced as well as native biofuel crops. In conclusion, certain parameters significantly differ between various native and introduced species of biofuel crops; however, the functional importance of these differences requires further research.

1. Introduction

Biofuel crops are plants grown for heating or production of biofuels. Their ecological benefits include reduced emissions of greenhouse gases, carbon sequestration and phytoremediation [1–3], but their impact on complex soil ecosystems still requires extensive research [4,5]. The main disadvantage of biofuel crops is their low economic competitiveness against fossil fuels [6,7]. Growing of biofuel crops can also cause competition over land with the need to grow food and forage [8], which may, consequently, compromise ecosystem services which soil provides [9]. The supposed economic benefit of these ecosystem services, including ecosystem services provided by soil organisms, for the human society is 33 T$ annually, although this is generally not appreciated [9].

Soil organisms are very important for decomposition of soil organic matter, humus formation and formation of soil microaggregates [10–12]. Increased production of biofuel crops causes loss of areas available for agricultural crops [8]. Biofuel crops are often introduced into new environments [4], which may potentially lead to changes to soil properties in these environments [13,14]. Gifford et al. [15] and Raghu et al. [4], for example, showed that certain biofuel crops such as *Arundo donax* and *Phalaris arundinacea* imported from temperate Europe and Asia to the USA are typical short-rotation grasses that become invasive in some US states and *A. donax* is invasive also in many parts of southern Europe [16].

Soil biota communities on arable land become depleted and host fewer species and functional groups of the soil biota [17–19]. Compared to the effect of cultural crops, which has been studied intensively [20,21], scant data are available on the impacts of biofuel plants. Many biofuel plants are perennials, which may be an advantage because, as already mentioned, tillage is the most important disturbance factor in agricultural soils [22,23] and perennials are also cheaper for the farmers [24]. On the other hand, many biofuel plant species are aliens, and some of them have been found to be invasive [4,14,25]. Many invasive plant species may negatively affect entire ecosystems [13,26–28]. Long-term mono-cropping cultivation of introduced crops may enhance this effect [14]. In this study, we explore the effects of growing various biofuel crops on the activity and composition of the soil biota. We in particular focus on the question whether there are any differences among individual native and introduced plant species.

The aim of this study was to test for differences in soil biological characteristics among introduced (*Helianthus tuberosus*, *Silphium perfoliatum* and *Reynoutria sachalinensis*) and native (*Salix viminalis* and *P. arundinacea*) biofuel crops in comparison with cultural meadow species used as control. We used the following characteristics: production of phenolic compounds, C:N ratio of plant litter, composition and abundance of various groups of soil fauna, composition and microbial biomass of soil microorganisms, biological activity of soil microbial biomass, basal soil respiration, and microbial biomass of carbon.

2. Material and methods

Sampling was performed in October 2009 in a split plot field experiment of the Crop Research Institute in the city Chomutov in the Czech Republic (50° 27′ 46″ N, 13° 24′ 40″ E, 7.86 °C mean annual temperature and 550 mm of annual rainfall). Soil samples were collected from field sites planted with five biofuel crops (*S. viminalis*, *P. arundinacea*, *H. tuberosus*, *R. sachalinensis* and *S. perfoliatum*) and a cultural meadow (overgrown by *Poa annua*, *Poa pratensis*, *Trifolium repens* and *Plantago major*) surrounding field sites planted with individual native and introduced plant species was used as control. Field sites planted with *S. viminalis*, and *P. arundinacea* represented native plant species. Other field sites were overgrown by introduced species (*H. tuberosus*, *R. sachalinensis* and *S. perfoliatum*). All crops were cultivated on field sites more than five years. Individual plant species were planted on three field sites separately in random order, whereas, one of each of the three field sites contained three sampled replicates. Experimental fields had 10 m length and 5 m width. A soil corer 12 cm in diameter was used to sample the soil fauna and 3 cm in diameter to sample the soil microflora, both down to the depth of 5 cm.

2.1. Overview of evaluated biofuel crops

S. viminalis is the common species of willow native to Europe and western parts of Asia. *S. viminalis* is commonly found on wet places. The exact native range is uncertain due to extensive historical cultivation [29]. This plant species is native in central Europe and west Asia [25]. Hybrids of some willow species are widely used as biofuel crops especially for bioenergy forestry [29].

P. arundinacea, also known as reed canary grass, is a tall, perennial bunchgrass that commonly forms single-species stands along the margins of lakes and streams and in wet open areas, with a wide distribution in Europe and Asia [30]. *P. arundinacea* growing well on nutrient poor soils as well as contaminated industrial sites and thus has large invasive potential in urban areas in its alien range [30]. *P. arundinacea* can also easily be turned into bricks or pellets for burning in biomass power stations [8].