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Potential of Short Rotation Coppice plantations to reinforce functional biodiversity in agricultural landscapes

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ABSTRACT

We compared communities of vascular plants and arthropods in ten Short Rotation Coppice (SRC)–maize pairs, to (1) quantify the difference in diversity and composition between these two alternative land-use types and (2) to assess the potential of SRC plantations to increase functional biodiversity values in agricultural landscapes. In each SRC plantation and maize field, the vegetation was surveyed and arthropods were sampled by applying pitfall and pan trapping. The composition of the vegetation and of the epigeic and vegetation inhabiting arthropod communities strongly differed between the crop types. This differentiation was mainly due to true species turnover and only to a lesser extent to the occurrence of nested subsets. On average, the total cover of the vegetation was 10 times higher in the SRC plantations and taxonomic and trait diversity were also consistently higher in SRC. Arthropod activity densities were significantly higher, sometimes almost double, in SRC plantations. Significantly higher effective species numbers in SRC were only retrieved for Hymenoptera and Coleoptera. Regarding functional groups, the activity densities of omnivores, detritivores, mycophages, phytophages and parasitoids were significantly higher in SRC. While activity densities of predators were not different among the crop types, their effective species number was higher in SRC, indicating a more evenly distributed and diverse predator community. To conclude, we have shown that SRC can significantly increase vegetation and arthropod abundance and/or diversity in agricultural landscapes when replacing annual biomass crops, such as maize.

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1. Introduction

Despite the recent 20th anniversary of the Convention on Biological Diversity, most indicators of the global state of biodiversity still show declines, with no significant recent reductions in rate [1]. This is particularly true for the intensively managed agricultural landscapes in northwestern Europe, where the combined effects of intensification practices since WWII on local (e.g. increased input of agrochemicals) and landscape scales (e.g. increased homogeneity, for instance due to simplified crop rotations) (cf. Refs. [2,3]), have caused an important biodiversity loss across different taxonomic groups and trophic levels (e.g. plants [4]; invertebrate predators and parasitoids [5] and farmland birds [6]). Furthermore, it is increasingly being recognized that biodiversity in agroecosystems is not functionally negligible and crucial to the delivery of key ecosystem services, such as pollination, pest and soil fertility regulation [7,8]. As an example, a positive link between landscape simplification and pest pressure, resulting in increased insecticide use, has recently been demonstrated [9].

Since 1992 (EEC Regulation 2078/92), the European Union (EU) has subsidized measures to conserve and restore farmland biodiversity within the framework of agri-environment schemes (AES; Refs. [10,11]). Despite the large budget devoted to AES (34 500 M€ for the period 2007–2013; Ref. [12]), biodiversity conservation measures on farmland often have no positive effects on biodiversity and sometimes even negative ones [11]. The latter authors also highlighted that biodiversity objectives are rarely clearly defined and that a different implementation and management strategy is needed when the focus is on intrinsic vs. functional aspects of biodiversity. Hence, there is a permanent need to develop both effective and efficient measures to meet the biodiversity targets. Especially since the EU has recently decided to enhance the environmental performance of the post-2013 Common Agricultural Policy (CAP) through a mandatory "greening" component of the direct payments to farmers [13].

Short Rotation Coppice (SRC) is a second generation energy crop in which fast growing trees are established, often on agricultural land, and harvested in rotations of 2–10 years, depending on tree species, environment and management conditions [14]. This bioenergy crop has a high energy output per unit of fossil energy input (e.g. Refs. [15–17,37]) and could also be beneficial for farmland biodiversity due to the generally low input of agrochemicals and the perennial nature of the crop. A review by Dauber et al. [18] confirms that SRC plantations indeed host a higher abundance and diversity of associated species than first generation, annual bioenergy crops, such as maize.

In densely populated regions with intensive agriculture, such as northwestern Europe, a large-scaled deployment of SRC will depend heavily upon the development of more favorable political and economic conditions, including lower SRC production costs, increased woodchip prices and subsidies [38]. However, smaller-scaled SRC-projects are feasible, especially when SRC is envisaged as a farmland biodiversity conservation measure that has the additional benefits of providing an alternative income to the farmer and helping to (partly) meet local demands for renewable energy. However, aiming at intrinsic biodiversity values (sensu [11]) with SRC is less relevant given the fact that SRC plantations are, both from a production and environmental perspective, ideally established on former arable land and given the fact that the disturbance frequency and intensity in SRC is still relatively high. Hence, the ecological contrast between SRC and conventionally managed farmland is relatively small. Based on Kleijn et al. [11], we therefore deduce that SRC as a farmland conservation measure should focus on enhancing functional biodiversity values. In that case, SRC is expected to have the largest effectiveness when it is applied in so-called structurally simple landscapes. Structurally simple landscapes, defined as landscapes with 2–20% semi-natural habitats by Tscharntke et al. [3], will benefit most from conservation measures because sufficient colonization sources are still present. However, colonization sources are expected not to be as abundant as in so-called complex landscapes where even low quality habitats can be biodiverse due to the spill over from the omnipresent high quality habitats. A recent meta-analysis by Batáry et al. [19] largely supported this hypothesis.

Given this conceptual and policy background, we assessed the potential role of SRC for functional biodiversity in structurally simple agricultural landscapes. This was achieved by comparing communities of vascular plants and arthropods in ten SRC–maize pairs, located in the northern part of Belgium and France. Our approach allowed us to (1) quantify the difference in diversity and composition between these two alternative land-use types and (2) to assess the potential of SRC plantations to increase functional biodiversity values in agricultural landscapes. Maize was deliberately chosen as alternative land-use option as it is currently the most important crop in Belgium (covering ca. 240 000 ha in 2012) and also the most important bioenergy crop (5000 ha planted in 2012) [20]. Furthermore, the environmental benefits (e.g. greenhouse gas savings: Ref. [17]) are expected to be highest when replacing annual crops with SRC. Indeed, in the predominantly agricultural landscapes of northwestern Europe annual crops are a more relevant reference bases than semi-natural habitats as, for instance, used by Fletcher et al. [21].

2. Material and methods

2.1. *Study sites*

Ten sites with SRC–maize pairs were selected. Eight sites were located in Flanders (northern Belgium) and two in northern France (close to the border with Belgium) (Table 1). In a first step, SRC plantations located in simple landscapes were searched for and in a next step a nearby maize field with similar site characteristics as the SRC site was selected. Doing so, the differences in possible confounding factors within the SRC–maize pairs were minimized. However, we decided to allow for variation in the characteristics (e.g. size, age, use of agrochemicals) of the selected SRC plantations, allowing to draw more general conclusions about the SRC–maize contrast. In 2010, the SRC sites were on average 5.9 years old, and the last harvest had taken place between one and four