OPINION

Introducing *Miscanthus* to the greening measures of the EU Common Agricultural Policy

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Abstract

The EU Common Agricultural Policy regulations for the 2014–2020 period comprise three ‘greening measures’ aimed at climate change mitigation and biodiversity conservation. These three greening measures consist of the maintenance of permanent pastures, crop diversification and ecological focus areas (EFAs). Farmers are to assign 5% of their land as EFAs; this concerns for example grassland, hedges, buffer strips or nitrogen-fixing crops. Short rotation coppice (SRC) as a perennial bioenergy crop is also considered as an eligible EFA within the EU greening measures, whereas *Miscanthus* is not. However, a quantitative comparison (t-test) of SRC and *Miscanthus* revealed that both crops are similar in the delivery of a variety of ecosystem services, such as C storage and biodiversity. Moreover, *Miscanthus* may contribute to the reduction of greenhouse gas emissions due to a considerable CO₂ mitigation potential. Due to the overall consensus of the ecological significance of *Miscanthus* in agro-ecosystems with the greening measures within the EU CAP reform, we recommend acknowledging *Miscanthus* as an eligible EFA with a similar payment as for SRC, boundary ridges or buffer strips. Along with *Miscanthus*, a number of other perennial renewables also may contribute to what the CAP intends. We predict that introducing *Miscanthus* and even other perennial energy crops could also make European agriculture more innovative and effective.

Keywords: biodiversity, carbon storage, climate change mitigation, ecological focus areas, ecosystem services, greening, *Miscanthus*

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Introduction

The Common Agricultural Policy (CAP) is a common policy for all member states of the European Union. The EU’s CAP is a dynamic policy, which has been adapted to new challenges including more sustainable use of natural resources, climate change, increased competition from global markets and the need to maintain thriving rural areas across the EU, while also providing sufficient high-quality safe food at affordable prices to consumers in the EU (European Commission 2013; BMEL, 2015). The reformed CAP includes (i) the ‘greening’ of farm payments, through the introduction of environmentally sound farming practices, (ii) more equality in the distribution of support across the EU, and (iii) better targeting of income support to farmers most in need, particularly young farmers, farmers in low-income sectors and farmers in areas with natural constraints (Lowe et al., 2002; European Commission 2016). The CAP’s pillar structure includes income support and market management measures (Pillar 1), while Pillar 2 covers rural development (European Union, EU, 2016).

In terms of greening European agriculture, the latest EU CAP regulations for the 2014–2020 period comprise three ‘greening measures’ aimed at climate change mitigation and biodiversity conservation (European Commission, 2015). These three greening measures consist of the maintenance of permanent pastures, crop diversification and the creation of ecological focus areas (EFAs), as proposed within the framework of Pillar 1 direct payments to farmers. Farmers must cultivate at least two crops when their arable land exceeds 15 ha and at least three crops when arable land exceeds 30 ha. The main crop may cover at most 75% of the arable land, and the two main crops at most 95% of the arable area. The ratio of permanent grassland to the total agricultural area must not fall by more than 5% compared to the reference year 2012. Moreover, farmers with over 15 ha of arable land are to assign 5% of their land as ecological focus areas, for example into fallow land, buffer strips or afforested areas. Organic farmers, who already apply environmentally beneficial practices, will have no additional requirements as their practices were shown to...
provide a clear ecological benefit already (European Environmental Agency, 2012). The introduction of ecological focus areas is expected to lead to a reduction in greenhouse gas emissions within the EU, mainly as a result of a reduction in fertilizer use. This aforementioned figure of 5% land as EFA is planned to rise to 7% after a Commission report in 2017 and a legislative proposal (European Commission, 2015). Accordingly, member states have to assign 30% of their budgets to direct payments for these measures. For the whole EU, this amounts to 13 billion euros annually (Westhoek et al., 2012).

The list of elements to be qualified as EFAs was established by Regulation (EU) No. 1307/2013 and is a political agreement on the recent CAP. By 1 August 2014, the EU member states have decided, which areas are to be considered to be ecological focus area (§ 46(2)). To finance the payment, member states can use 30% of the annual national ceiling set out in Annex X of Regulation 639/2014 (European Union, 2014). Notably, short rotation coppice (SRC) as a perennial land-use type has been considered in the greening measures by a weighting factor of 0.3, whereas Miscanthus was not considered as EFA.

In this opinion paper, we focus on the restrictions made within these EFA rules, specifically on Miscanthus, which is increasingly recognized in European agriculture as a renewable energy resource. Miscanthus beneficially impacts both farmland biodiversity and reduce greenhouse gas emissions due to a considerable CO2 mitigation potential (Baum et al., 2012; Don et al., 2012; Felten et al., 2013; McCalmont et al., 2015; Milner et al., 2015). Because of these and other benefits, we strongly recommend the recognition of Miscanthus crops as ecological focus areas within the greening payment rules.

A brief overview of ecosystem services of Miscanthus

Due to low fertilizer and weed control requirements, long growth periods of up to 25 years, no-till cultivation and high yield potential, Miscanthus can currently be regarded as a low-input crop, characterized by a high-energy output: input ratio (Lewandowski et al., 2005; Clifton-Brown et al., 2008). Similar to SRC, Miscanthus confers a broad set of benefits on the agri-environment (Lewandowski et al., 1995; Clifton-Brown et al., 2007).

C storage

The carbon storage potential in Miscanthus stands has been shown to range between 0.9 and 2.2 g C kg⁻¹ soil yr⁻¹ (Kahle et al., 2001) and from 0.7 to 2.2 Mg C₄-C ha⁻¹ yr⁻¹ (McCalmont et al., 2015). Within 16 years of continuous farming, Miscanthus stands accumulated a total of 17.7 Mg C ha⁻¹ in the top 60 cm of soil derived from Miscanthus residues (C₄-C), which is equivalent to 1.1 Mg C ha⁻¹ yr⁻¹ for that soil depth (Felten & Emmerling, 2012). Schneckenberger & Kuzyakov (2007) concluded that the carbon accumulation in soil under Miscanthus was similar to that under permanent grassland. The potential of C storage in addition to no-till cultivation and less plant nutrition and protection (which in practice is carried out in the first 2–3 years) may also positively affect soil stability, that is aggregate stability, and thus, potential soil erodibility (McCalmont et al., 2015; Schrama et al., 2016). Specifically, soil quality was significantly improved through the conversion for example of maize monoculture to perennial second generation (2G) bioenergy crops, for example SRC, Miscanthus, switchgrass and giant reed (Chimento et al., 2016).

Biodiversity

Many studies on Miscanthus and other perennial 2G bioenergy crops reported positive effects on species and habitat diversity, when they replace arable land use, but this strongly depends on the respective field-scale management (Bellamy et al., 2009; Dauber et al., 2010; Sage et al., 2010; Baum et al., 2012; Schrama et al., 2016). According to Jodl et al. (1998), the species number of beetles and spiders was higher, their distribution was more stable and a high number of species were only found in Miscanthus stands compared to maize fields. Moreover, Miscanthus may function as a substitute for trees and hedges in agrarian landscapes, specifically for large mammals, such as deer and hare, for birds like quail or grey partridge, as well as for large predators, as it is often a retreat for game animals mainly in winter (Jodl et al., 1998; Kohli et al., 1999). Miscanthus may provide useful cover and roosting sites for some bird species in winter, particularly for a high number of endangered species (Anderson et al., 2004). With regard to a comparison of Miscanthus for example with SRC, it can be concluded that both will have a different impact on species abundance, diversity and community structure. Where Miscanthus replaces arable crops, the impact on biodiversity can be positive. However, there are reservations. For example, Sage et al. (2010, reviewed by Immerzeel et al., 2014) concluded that Miscanthus would have a roughly neutral overall effect on bird species.

CO₂–mitigation

The annual surplus of carbon storage in Miscanthus stands is a CO₂ credit within a greenhouse gas balance. Miscanthus is one of the very few crops worldwide that...
reaches true CO₂ neutrality and may function as a CO₂ sink (Felten et al., 2013). In short, Miscanthus as a fuel oil substitute provides more energy than is required for its cultivation. Related to the combustion of fuel oil, the direct and indirect greenhouse gas emissions can be reduced by a minimum of 96% through the combustion of Miscanthus straw (emissions: 0.08 kg CO₂-eq MJ⁻¹ (fuel oil) vs. 0.0032 kg CO₂-eq MJ⁻¹ (Miscanthus straw)). Due to the C-sequestration during Miscanthus growth, this results in a CO₂-eq mitigation potential of 117% (Felten et al., 2013).

Commercial relevance

The commercial relevance of Miscanthus is not restricted to its use for combustion. Recently, Mayer et al. (2014) recorded a considerable biochemical methane potential for premature Miscanthus as a feedstock for biogas plants. Moreover, a broad set of industrial applications, such as litter, especially in horse stalls or for gardening is documented (Pude et al., 2004). In the building industry, it is increasingly applied as an environmentally friendly building material (Pude et al., 2005).

Quantitative comparison of ecosystem services of SRC and Miscanthus

Due to the provision of greater ES compared to arable land use, SRC (e.g. willow, poplar) are considered as an eligible EFA within the EU greening measures, whereas Miscanthus is not. We therefore conducted a quantitative comparison of SRC and Miscanthus relative to reference crops by a t-test (Welchs t-test; R Core Team, 2015) using available data in the literature. We used published studies concerning the impact of SRC and/or Miscanthus relative to mainly arable land use by example of C storage and biodiversity as response variables. As an exception, grassland as a control site was also considered in a few cases. From the available data, we calculated the percentage deviation of the C amount of top soils and plant and animal biodiversity indicators of SRC or Miscanthus relative to the reference sites. Our criteria for the choice of published data were as follows: (i) only significant results were used, (ii) for SRC, only poplar or willow was considered, (iii) arable land use was mainly maize or cereals (rapeseed as an exception), (iv) soil C amounts were restricted to the top soil, (v) for the response variable, ‘biodiversity’ data of plants and animals (e.g. birds, small mammals, invertebrates, ground beetles, carabid beetles, butterflies, spiders and earthworms) were considered, and (vi) the duration of the field experiments was a minimum of >2 years. By this, between 14 and 19 publications for C storage and biodiversity as response variables of SRC and Miscanthus cultivation, respectively, were considered (Appendix Table S1).

As the main result, the t-tests revealed that SRC and Miscanthus showed similar effects on C storage and biodiversity (Fig. 1). The differences between SRC and Miscanthus were not significant in either case (C storage: \( P = 0.6303 \); biodiversity: \( P = 0.3704 \)). The mean response of both crops on C storage was approx. +18% related to the reference sites, and as such, this was comparable to the C stock increase for the transition from annual crop to plantations according to a meta-analysis published by Guo & Gifford (2002). The mean response of both crops for indicators of biodiversity was much higher and approx. +50% (SRC) and +63% (Miscanthus) related to the reference sites (Fig. 1). These results emphasize that both crops may have a significant positive impact on C storage and biodiversity in agro-ecosystems in a similar manner.

Recognizing Miscanthus as ecological focus areas

All in all, it is likely that Miscanthus cultivation is compatible with the greening agenda of the EU CAP reform, particularly concerning climate change mitigation and biodiversity conservation. Moreover, the planting of Miscanthus in buffer strips, may have additional environmental advantages, such as reducing the leaching and run-off of nutrients and pesticides into surface waters (Dimitriou et al., 2012a; European Environment Agency, 2012). This might be attributed to a well-established and active root system enabling Miscanthus to use nutrients late in the vegetation season. In a comment paper, the German Federal Agency for Nature Conservation (BfN) together with the Environmental Protection

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Agency (UBA; BfN, 2014) recommended ecological minimum criteria to be met for ecological focus areas, such as a principal exclusion of chemical weed control or mineral fertilization (cf. §46 of the Regulation (EU) 1307/2013; European Union, 2013). Miscanthus could meet these criteria, as the exclusion of pesticides and mineral fertilizers is possible throughout the growth period, and their application should be generally omitted when recognized as EFA. We hypothesize that this could lead to positive drawbacks (reduced use of fertilizers and pesticides) at a landscape scale.

However, according to Manning et al. (2015), there is a need to develop novel landscape management strategies for 2G bioenergy crops at different scales. A small-scaled mosaic of different 2G bioenergy crops may therefore develop diverse habitats and refuges for a number of species and may help to enhance biodiversity in agricultural landscapes (Felfen & Emmerling, 2011), including the potential for spillover of ecosystem services, for example beneficial insects, into neighbouring areas (Manning et al., 2015).

Additionally, the cultivation of Miscanthus could provide a coherent set of interventions that address two key challenges simultaneously, (i) greening the European agriculture sector through reducing environmental impacts, and (ii) ensuring renewable energy production. Thus, introducing Miscanthus as ecological focus areas could contribute to a more innovative and effective European agriculture in the future.

Outlook

Due to the overall consensus of the ecological significance of Miscanthus in agro-ecosystems with the greening measures within the EU CAP reform, aiming at climate change mitigation and biodiversity conservation, we recommend that Miscanthus be acknowledged as an ecological focus area on the EU regulation list. According to the available literature, SRC is eligible as an EFA because it provides greater ecosystem services compared to traditional arable land use. The quantitative comparative approach of the effects of Miscanthus and SRC relative to arable land use revealed that both are similar in the delivery of a variety of ecosystem services. Thus, Miscanthus should also be considered for inclusion as an eligible EFA with a similar payment (weighting factor of 0.3) as for SRC, boundary ridges or buffer strips (cf. Annex X of the EU Regulation 639/2014, European Union 2014). This could be achieved through a supplementary regulation of the European Parliament and of the Council establishing rules for direct payments to farmers within the next Commission report in 2017 and a legislative proposal. In practice, however, it is essential that one member state will recommend Miscanthus as an eligible EFA to the Commission.

Moreover, there is increasing evidence that along with Miscanthus, a number of other perennial renewables, such as Silphium perfoliatum, may also have the potential to be considered for inclusion as eligible EFA to make European agriculture ‘greener’ (Emmerling, 2014). Finally, we recommend introducing Miscanthus and even other perennial energy crops to make European agriculture more innovative and effective.

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Supporting Information

Additional Supporting Information may be found online in the supporting information tab for this article:

Table S1. Data sources for the quantitative comparison of SRC and Miscanthus.