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Weed control method drives conservation tillage efficiency on farmland breeding birds

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ABSTRACT

Crops management is known to influence biodiversity, especially conservation tillage (CT, no-till) often found as a positive method compared to conventional tillage (T, inversion of soil) but without controlling for underlying farming practices. There are many ways to perform CT, in particular concerning the control of weeds, but few studies have taken into account these methods, which could explain the lack of consensus about the effect of CT compared to T. We tested differences in breeding birds abundance between CT and T while accounting for weed control methods in oilseed rape and wheat CT fields. During the intercrop period, one CT system used a cover crop to control weeds (CTcc), the other used herbicides (CTh) and the control (T) system only used a tillage. We made CTcc/T and CTh/T comparisons by sampling bird abundance (respectively 49 CTcc/51 T and 30 CTh/33 T point counts). We show substantial differences between CTcc/T and CTh/T comparisons as we detected greater bird abundances in CTcc than T for 5 species (2.3–4.1 times more individuals) and a lower abundance in CTh than T for 2 species (2.1–2.2 times less individuals). Our results demonstrate the importance to account for system features to ensure the CT efficiency for farmland birds, declining strongly in Europe since 1980 (−55 to −67%). Results also highlight an even more negative impact of herbicides than tillage, showing that stopping tillage to intensify herbicide use is not a promising way.

1. Introduction

Historically, agricultural areas, and more specifically arable lands, represent an important proportion of Europe (respectively 35.6 and 21.1%; Eurostat, 2016a). Changes in farmland, such as intensification processes including increased use of fertilizers, pesticides, and homogenization of the farming landscape in space and time, are the main causes of decline in the diversity and abundance of wildlife (Bengtsson et al., 2005; Benton et al., 2003). These effects have been observed on many taxa in Europe (e.g. plants and invertebrates: Wilson et al., 1999; birds: Donald et al., 2001; bats: Wickramasinghe and Jones, 2003; moths: Fox, 2013). The Common Agricultural Policy (CAP) has been, and still is, a major driving force behind land use intensification through the stimulation and modernization of agricultural production (Van Zanten et al., 2014). Since 2013, the CAP includes new greening requirements (e.g. reduction of grassland fertilization, grass strips, mowing deferment, flowery fallows) such as ecological focused areas (EFA, direct payments in the first pillar) and changes in agri-environmental schemes (AES) including agri-environmental managements (AEM, payments on a voluntary basis in the second pillar). Within the European policy, greening measures are increasingly claimed to be important tools for the maintenance and restoration of farmland biodiversity in Europe. While AES do not result in a decrease of crop yields (Pywell et al., 2015), so far they have only had marginal to moderate positive effects on biodiversity, especially because they do not differentiate common and endangered species and are applied on too small and/or wild areas (Kleijn et al., 2006). The CAP also encourages farmland to be managed as EFA in order to maintain biodiversity. These EFA, covering 3–7% of European farms, can contribute to increase richness of species, but differences between the 3 and 7% limits were considerable for butterflies, birds and hoverflies (Cormont et al., 2016). In addition, a meta-analysis conducted by Batary et al. (2011) showed that AEM were not a very efficient way of spending the limited funds available for biodiversity conservation on farmland. While AEM and EFA can concern a few Used Agricultural Area in Europe (Eurostat, 2009), extensification of cropping practices could positively affect farmland biodiversity on larger surfaces (Fuller et al., 2005). Some of these cropping practices, such as lengthening and diversification of crop rotation (Josefsson et al., 2016; Miguet et al., 2013) and the reduction of soil tillage (Holland, 2004), have been identified as providing more

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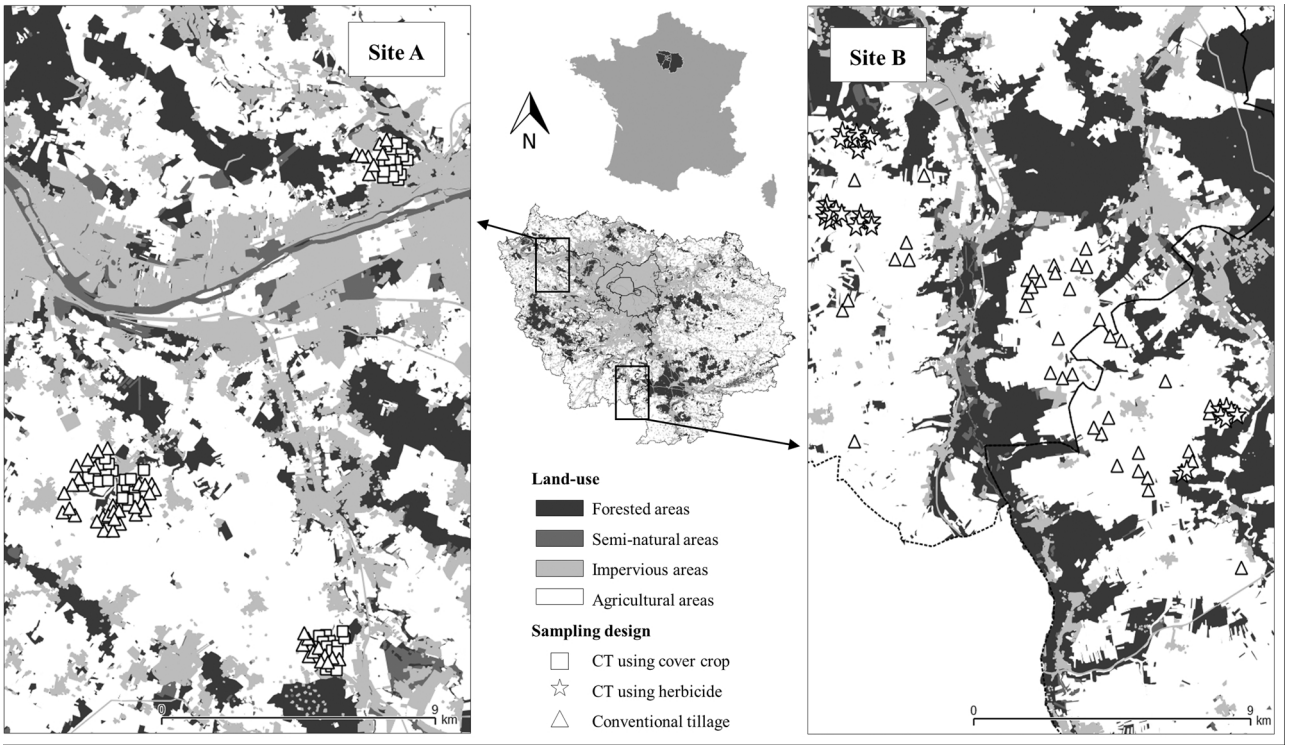

Fig. 1. Land-use map of the two study areas in Île-de-France region showing sampling points of conservation tillage (CTcc, CTh) and conventional tillage (T).

favourable conditions for biodiversity in farmland. Such alternative practices are not included in AES/AEM and EFA policies.

Compared to conventional tillage (inversion of soil with a minimum of 30 cm depth), conservation tillage (i.e. non-inversion of soil) can have beneficial consequences on soil structure and fertility, soil organic carbon sequestration, crop diseases and pests, hydrology and water quality regulation, weed control (Holland, 2004; Kuhn et al., 2016; Power, 2010; Soane et al., 2012; Tamburini et al., 2016b), and biodiversity (Boscutti et al., 2014; Holland, 2004; Kladivko, 2001). Therefore, it is expected to have positive effects for many taxa such as flora, soil fauna and birds (Holland, 2004). However, this effect is strongly modified regionally nearly for all taxa (Tryjanowski et al., 2011; Sutcliffe et al., 2015). It was also found to improve aphid predation, and to mitigate the negative effects of landscape simplification on biological control (Tamburini et al., 2016a). Several studies have shown that the abundance and diversity of bird species during the breeding period was higher in conservation tillage fields (Flickinger and Pendleton, 1994; Lokemoen and Beiser, 1997; Shutler et al., 2000). Positive effects of conservation tillage have also been identified in the wintering period, with a higher abundance of seed-eating birds on arable fields compared to conventional tillage (Field et al., 2007). However, at the community level, Filippi-Codaccioni et al. (2009) did not detect any differences in habitat specialist species abundance between conservation and conventional tillage. Moreover, they found that farmland specialist bird species have lower abundance in conservation tillage compared to conventional tillage (Filippi-Codaccioni et al., 2009), including some farmland flagship species such as the Eurasian skylark (*Alauda arvensis*).

Thus, according to published studies, there is no consensus on the net effect of conservation tillage. Possibly, this lack of consistent effects of conservation tillage could be linked to variations in other farming practices associated to conservation tillage and especially the method used to control weeds (combining cover crop or superficial tillage with herbicide, or using herbicides only). However, few of the published studies accurately specified the method of weed control occurring between harvest of the previous crop and seeding of the new one, and in the case of cover crop, how this cover is destroyed before seeding the next crop (Field et al., 2007; Filippi-Codaccioni et al., 2009; Flickinger and Pendleton, 1994; Lokemoen and Beiser, 1997; Shutler et al., 2000). In addition, the study that best describes practices during the intercrop (Field et al., 2007) did not conduct bird counts during the breeding period of birds.

To our knowledge, only one study (VanBeek et al., 2014) compared two systems of weed control in conservation tillage in soybean crops: (i) a superficial tillage (8–10 cm depth), using a cultipacker to smooth the soil surface and (ii) a no-till with direct seeding into the soil surface between rows of standing corn stubble (previous crop). In both systems, weeds were further controlled with a non-selective herbicide after seeding. The study found the highest bird nesting density in the no-till system (VanBeek et al., 2014). However, the study did not compare these systems with conventional tillage.

Hence, there is a need to assess the conservation tillage impact on biodiversity compared to conventional tillage according to the weed control method to untangle ambiguous results from previous studies. To take into account underlying weed control method of conservation tillage types, which in turn could affect the response of farmland birds, this study is placed at the conservation tillage system level. Thus, we compare the abundance of breeding farmland bird species of two conservation tillage systems with conventional tillage in wheat and oilseed rape crops: (1) conservation tillage using a cover crop *vs*. conventional tillage, and (2) conservation tillage using only herbicide *vs*. conventional tillage. There is no soil-inversion and no superficial tillage in both conservation tillage systems.

2. Materials and methods

2.1. Study area and sampling design

The study was conducted in France, in the Île-de-France region (Essonne, Seine-et-Marne and Yvelines departments), in an intensive agricultural landscape with a higher yield production than the national average except for sugar beet (Appendix A, Table A1, Supplementary material). This region is covered by 59% agricultural areas, 22% forest

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