Available online at www.sciencedirect.com
ScienceDirect
Agriculture, Ecosystems and Environment 120 (2007) 399–404
Agriculture Ecosystems & Environment
www.elsevier.com/locate/agee

Influence of conservation tillage on winter bird use of arable fields in Hungary

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Received 25 May 2006; received in revised form 9 October 2006; accepted 20 October 2006
Available online 22 November 2006

Abstract

Bird use of conservation tillage-established (CT—seedbed preparation without soil inversion) crops was assessed at two adjacent sites in western Hungary, in comparison with conventionally established (mouldboard ploughed—P) fields. Bird abundance was assessed in a typical rotation of spring-sown maize and winter wheat in three consecutive winters. In the first winter, several species and the guild of seed-eating passerines were significantly more abundant on CT established plots, in both crop types. In the second winter, only starlings were more abundant on CT plots. In the third winter, only skylarks favoured CT over P plots. In combination with agri-environment scheme measures designed to provide resources for biodiversity, conservation tillage could play a role in softening the impact of agriculture on farmland birds in Hungary and elsewhere in Eastern Europe, in addition to its potential for reducing soil erosion and diffuse pollution.

Keywords: Conservation tillage; Birds; Intensification; Winter resources

1. Introduction

Recent population declines of European farmland birds have been linked primarily to agricultural intensification (e.g. Donald et al., 2001), largely driven by the Common Agricultural Policy (CAP) within the European Union (EU). However, some farmland bird species which have suffered declines within established EU member states are still relatively abundant on farmland in Hungary, a new EU state, even on intensively managed land (Szép and Nagy, 2002; Verhulst et al., 2004). Now that several Eastern and Central European countries have joined the EU, the expansion of the influence of the CAP to countries like Hungary could speed up the intensification of their agriculture (Hertel et al., 1997). Intensification of management is leading to large bird population declines in both vineyards and grassland in Hungary (Verhulst et al., 2004). Bird populations in the new member states will, however, face these challenges in a changed economic environment, with the recent changes in CAP funding focussing on improving the environmental performance of farming through subsidy, rather than being production driven. Indeed, many countries throughout the EU now provide direct funding for environmental benefits of farming through agri-environment schemes, and Hungary is no exception (Ángyán et al., 1999) (although CT is not currently an agri-environment option in Hungary). Additionally, farm sizes (traditionally small in Hungary, except during the period of socialist rule, 1950–1989) are likely to increase in the future (Ángyán, 2004), so any land management changes will have an effect over large contiguous areas.

In the UK, reduction in annual survival rates seem to have been critical for some granivorous bird species in particular (Peach et al., 1999; Siriwardena et al., 2000), and have been linked to reductions in the availability of food (particularly weed seed and crop grains) during winter. This in turn results

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0167-8809/$ – see front matter
doi:10.1016/j.agee.2006.10.014

from loss of over-winter stubbles with the switch from spring to autumn sowing of crops, increased agro-chemical usage, more efficient mechanical harvesting and improved bird-proofing of grain stores (Campbell et al., 1997; Hole et al., 2002; Newton, 2004). In winter, seed-eating birds now strongly avoid ploughed fields, because of lack of seed food (Wilson et al., 1996). Over-wintered stubbles are now regularly associated with greater winter bird abundance (e.g. Evans and Smith, 1994; Moorcroft et al., 2002; Wilson et al., 1996) and have been shown to be associated with enhanced local breeding bird densities, presumably by enhancing survival rates (Gillings et al., 2005). Studies on reed buntings in Poland have reported similar findings (Orlowski, 2005), this species favouring weed-rich winter stubbles and root crops, and avoiding ploughed fields and winter cereals as winter foraging habitats.

There is evidence from the USA that spilt grain and weed seed abundance are higher on Conservation Tillage (CT) (seedbed preparation without soil inversion) fields than ploughed fields during winter, at least partially mimicking stubble fields, and that winter bird use of CT fields is consequently higher (Baldassarre et al., 1983). However, there has been little work examining responses of birds in winter to CT fields in Europe, since most CT studies have been at a scale too small to demonstrate any influence on bird behaviour (Holland, 2004). Where work has been done, the results have often been inconclusive or confounded with other factors (Higginbotham et al., 2000; Saunders, 2000). In the UK, the occurrence of granivorous birds was higher on CT-established fields than fields established by ploughing, across a range of crop-types (Cunningham et al., 2005). Here we present evidence of an association between farmland birds and conservation tilled fields in winter in a common crop rotation in Hungary.

2. Methods

Bird surveys were undertaken as part of the SOWAP (Soil and Water Protection) project. SOWAP is a multidisciplinary, multi-agency, 'EU Life' demonstration project examining the agronomic, biodiversity, soil and water quality and erosion benefits of CT in several European countries (www.sowap.org). Surveys were conducted in the winters of 2003–2004, 2004–2005 and 2005–2006 at two locations near the village of Dióskál (46°40′0 N, 17°3′0 E) in western Hungary. Both locations consisted of single large fields. Dióskál 1 (67.3 ha) was divided into eight pairs of plots of approximately equal size (~4 ha). These plots were sown with a typical rotation of winter wheat after spring maize in the first winter, spring maize after winter wheat in the second, and winter wheat after spring maize again in the third. Dióskál 2 (37.6 ha) was divided into four pairs of ~4 ha plots and was sown with spring maize after winter wheat in the first winter, winter wheat after spring maize in the second and spring maize after winter wheat again in the third winter. In each plot pair, at both sites, the crop in one plot was established by conventional mould-board ploughing (P), and the adjacent one by conservation (non-inversion) tillage, by disc to a depth of 8–10 cm. The CT methodology for spring maize establishment differed between winters, reflecting different SOWAP trials for soil erosion. In 2003–2004, after winter wheat harvest, P plots at Dióskál 2 were ploughed, and remained bare until seedbed preparation in April 2004. The paired CT plots were left fallow after harvest until spring crop establishment. In the second winter, P plots at Dióskál 1 were again over-wintered as bare plough, but the paired CT plots were non-inversion cultivated in autumn and sown with an oil-seed rape cover crop, in the anticipation that vegetation cover would increase surface roughness and therefore water infiltration, so as to reduce soil erosion. This cover crop was incorporated into the soil surface by disking immediately prior to maize establishment. In the third winter, crop establishment was as in the first winter. Amounts of chemical inputs to the two treatments were very similar, for both crops (Table 1).

Bird distribution and abundance were estimated using established methods of field usage assessment for farmland birds in winter (Bradbury et al., 2004). A single observer (SB) walked parallel transects perpendicular to the longest axis of plots, at 20 m intervals, counting all birds flushed. Double counting was avoided by noting where previously flushed birds landed. In winter 2003–2004, at least three visits were made to each plot in each month, between December 2003 and the end of March 2004, with two visits made to Dióskál 1 plots and one to Dióskál 2 plots in November 2003. In the second (2004–2005) and third (2005–2006) winters, a minimum of three visits per month was made to each pair of plots from the beginning of October until the end of March. Surveys began at least 1 h after dawn and were completed by at least 1 h before dusk, to avoid counting or missing birds leaving, or arriving at, roost sites. Counts were not conducted during periods of wet or windy weather because of the effects of these conditions on bird activity and detectability. Census routes were reversed between visits. Plots were scored according to whether there were adjacent, non-cropped areas that were likely to provide alternative weed-seed or invertebrate feeding opportunities for passerines, which might confound counts with respect to tillage regime.

3. Statistical analyses

Data from Dióskál 1 and 2 (at different stages in crop rotation) and from each winter were analysed separately. The effect of tillage method on the abundance and distribution of birds was tested using binomial logistic regression, in the GENMOD procedure of SAS Version 9.1 (SAS Institute, 2003). Plot identity was specified as a repeated measure in the model, since the same plots were counted repeatedly during the winter. The number of visits in

Table 1
Average amount of chemical inputs each year for each treatment and crop

	Winter wheat		Maize	
	Ploughed	Conservation tillage	Ploughed	Conservation tillage
Nitrogen	350 kg/ha	350 kg/ha	383 kg/ha	287 kg/ha
NPK	133 kg/ha	133 kg/ha	133 kg/ha	133 kg/ha
Herbicide	0.14 kg/ha	0.14 kg/ha	2.1 l/ha	1.95 l/ha
Fungicide	1 l/ha	0 l/ha	0	0
Insecticide	0.13 l/ha	0.13 l/ha	0	0

Table 2
Functional/taxonomic species groupings used for bird analyses

Grouping	Species	Total numbers recorded		
		2003–2004	2004–2005	2005–2006
Granivorous passerines	Tree sparrow *Passer montanus*, yellowhammer *Emberiza citrinella*, chaffinch *Fringilla coelebs*, goldfinch *Carduelis carduelis*, greenfinch *C. chloris*, lesser redpoll *C. cabaret*, brambling *F. montifringilla*, linnet *C. cannabina*, reed bunting *E. schoeniclus*	1204	1004	1046
Corvids	Jay *Garrulus glandarius*, carrion crow *Corvus corone*, jackdaw *C. monedula*, magpie *Pica pica*, rook *C. frugilegus*	59	206	129
Invertebrate feeders	White wagtail *Moticilla alba*, blackbird *Turdus merula*, starling *Sturnus vulgaris*, fieldfare *T. pilaris*, stonechat *Saxicola torquata*	135	1190	15,417 (15,000 starlings in two flocks)

each month in which a plot (CT or P) held a greater abundance of a species or functional group (Table 2) than its paired counterpart was specified as the response variable, and the number of visits made in that month was the binomial denominator (Butler et al., 2005). Binomial error structure and logit link function were specified, controlling for any overdispersion. The natural logarithm of plot size (ha) was included as an offset variable, controlling for the effects of variation in plot area on bird abundance. The term 'month' was included in models to investigate whether the relative abundance of birds on CT and P plots changed over the course of the winter. In addition, the term 'Edge' was included in models. This was a categorical binomial variable, representing whether (1) or not (0) there were any significant weedy non-cropped habitats immediately adjacent to each plot which may have influenced the presence of birds on those plots. These methods represent a biologically realistic approach, removing pseudoreplication caused by non-independence of conspecifics in a flock, while still allowing investigation of variation in numbers of individuals using a habitat, which may indicate the relative values of habitats as foraging sites (Buckingham et al., 1999; Butler et al., 2005). All probabilities quoted are two-tailed.

4. Results

The weather in the three winters of the survey varied considerably, with the first being the mildest, the second and third being progressively colder. The number of days with ground snow cover at Dióskál increased from 29 in the first, 49 in the second to 70 in the third.

4.1. Winter 1—2003–2004

In total, 1828 bird records were made, comprising 24 species, 1572 on CT plots and 256 on P plots (Fig. 1a). Apart from skylark *Alauda arvensis* (241 records) and goldfinch (711 records), no bird species were recorded in sufficient numbers to permit statistical analysis at the species level. Therefore, species were assigned to functional species groupings, based on foraging requirements and taxonomic affiliations (Bradbury and Allen, 2003: Table 2). Bird records do not represent counts of individuals, since some individuals may have been counted several times over a winter. Therefore, counts were analysed in terms of bird relative encounter rates.

No species or group showed a significant change in relative abundance on CT and P plots between months. Both skylarks and other seed-eating passerines were more abundant on CT than P plots, at both Dióskál 1 and 2 (though the effect was not significant for seed-eating passerines at Dióskál 2) (Table 3). Goldfinches were more abundant on CT plots than P plots at Dióskál 1, but a viable model could not be constructed for goldfinches at Dióskál 2. Corvids were more abundant on CT than P at Dióskál 2 but not at Dióskál 1. There were no significant differences in the relative abundance of invertebrate-feeding birds on CT and P plots at either Dióskál 1 or 2. There were no significant effects of adjacent non-cropped habitats on the abundance of any species.

4.2. Winter 2—2004–2005

Although the total number of birds recorded (5837) was higher than in 2003–2004, 3133 of these were geese. These birds, of three species (white-fronted goose (*Anser albifrons*),

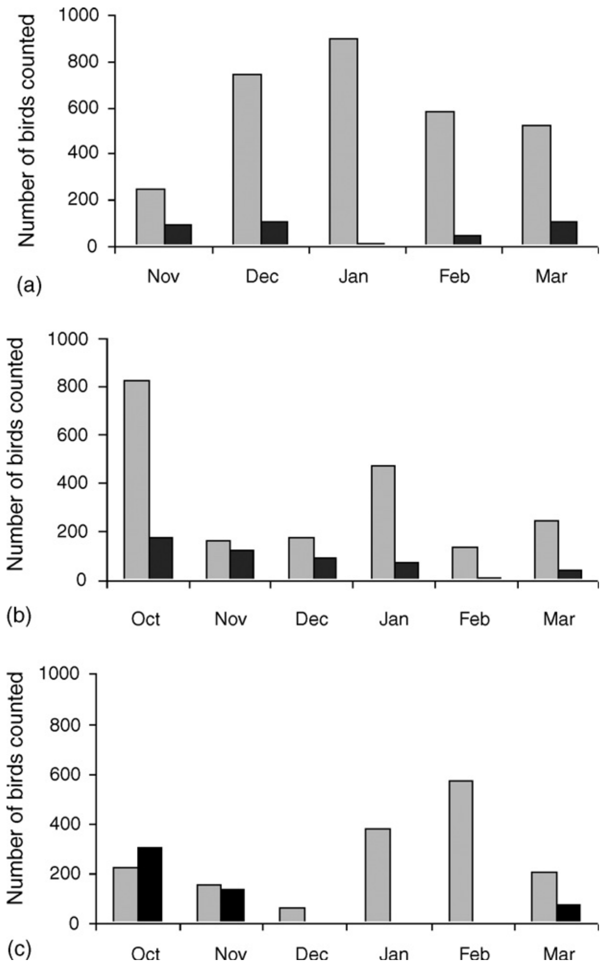

Fig. 1. Monthly total bird numbers on CT and P plots summed for Dióskál 1 and 2 for winters (a) 2003–2004, (b) 2004–2005 and (c) 2005–2006. Grey bars CT, black bars P.

bean goose (*A. fabalis*) and greylag goose (*A. anser*)), occurred only on four separate occasions, as part of very large flocks. These data were therefore too sparse, in terms of rate of plot occupancy, to be analysed. Our own observations, however, suggest that foraging geese preferred to forage on the post-harvest residue (particularly maize) left on CT plots than on the cultivated P plots. The total number of species recorded was 33. The number of individuals of all species other than geese (2704) was higher than that in the winter of 2003–2004, with 559 of these on P plots and 2145 on CT plots (Fig. 1b). Goldfinch (252), skylark (207), brambling (324) and starling (1000) were sufficiently abundant to allow single species analyses, though there were insufficient data to be able to produce a viable model for goldfinches at Dióskál 2. The remainder of analyses were conducted on functional and taxonomic groupings as above (Table 2).

No species or functional group showed any monthly variation in relative abundance on either CT or P plots. Indeed, it was only possible to produce viable models including the 'month' term for species groupings, due to sparseness of individual species data. Only starlings showed any variation in abundance with tillage, being significantly more abundant on CT plots than on P plots at Dióskál 1 (Table 3). Invertebrate feeders showed a significant tendency towards feeding on plots adjacent to areas of high food density non-cropped habitat.

4.3. Winter 3—2005–2006

In the final winter, the total number of bird registrations was again increased, with 20,836 birds being recorded during all visits. However, a large proportion of this total was due to two very large flocks of four species, present on the site for very short periods. In November 2005, a large flock (approximately 1500 birds) of three species of geese (white-fronted goose, bean goose and greylag goose) were present at Dióskál 1 for most of the month, accounting for 3682 of the 3980 counted birds. These birds were not seen at the site in any other month. Similarly, in March 2006, the total count was over 15,000, but this is largely accounted for by single sightings of two large flocks (one of 14,000 and one of 1000) of starlings. These large flocks were excluded from analyses because of data sparseness as above. Excluding these large flocks, 2154 birds were counted, 547 on P plots and 1607 on CT plots (Fig. 1c). Skylarks (272) were sufficiently abundant to allow single species analysis. A number of other species (brambling (200), linnet (376), yellowhammer (198) and fieldfare (191)) were similarly abundant, but occurred sufficiently infrequently and in relatively large flocks, such that analyses failed due to data sparseness. The remainder of analyses were conducted on functional and taxonomic groupings as above (Table 2).

Only two taxonomic groups were recorded frequently enough through the winter to produce viable models incorporating a month term. Neither granivorous passerines at Dióskál 1 nor corvids at Dióskál 2 showed any significant seasonal pattern of abundance. Only skylarks showed a significant difference in abundance with tillage, being significantly more likely to be encountered on CT plots than P plots at Dióskál 1 (Table 3). There were no significant effects of adjacent non-cropped habitats on the abundance of any species.

5. Discussion

Our results suggest that CT may be attractive to seed-eating birds using farmland in Hungary. However, whilst there were strong associations between a number of species/functional groups and CT in the first winter of the study, these were not apparent to the same degree in the second or third winters. Granivorous passerines were more abundant at Dióskál 1 in the first winter than the second, with nearly 60% of these being goldfinches in winter 1, but only 25% in winter 2. Only 11 goldfinches were recorded at Dióskál 1 and 2 for the whole of winter 3. The significant association between granivores and CT seen in 2003–2004 at Dióskál 1

Table 3
Results of logistic regression analyses for three species and three functional groups of birds recorded on experimental plots at Dióskál in three winters

	2003–2004		2004–2005		2005–2006	
	Model goodness-of-fit	Tillage	Model goodness-of-fit	Tillage	Model goodness-of-fit	Tillage
Dióskál 1						
Crop	Spring maize → winter wheat		Winter wheat → spring maize		Spring maize → winter wheat	
Skylark	0.9278	**<0.005 (CT > P)**	1.5752	NS	0.5659	**<0.05 (CT > P)**
Granivorous passerines	1.2718	**<0.005 (CT > P)**	1.6113	NS	0.7661	NS
Goldfinch	0.8755	**<0.005 (CT > P)**	1.1207	NS		
Corvids	0.6617	NS	1.2152	NS	0.6329	NS
Invertebrate feeders	0.8008	NS	0.8629	NS	0.6526	NS
Starling			0.4805	**<0.05 (CT > P)**		
Brambling			0.2385	NS		
Dióskál 2						
Crop	Winter wheat → spring maize		Spring maize → winter wheat		Winter wheat → spring maize	
Skylark	0.9695	**<0.05 (CT > P)**	0.7054	NS	2.1093	NS
Granivorous passerines	1.5664	NS	1.4036	NS	0.9676	NS
Corvids	0.6913	**<0.05 (CT > P)**	1.0403	NS	1.1710	NS
Invertebrate feeders	0.6372	NS	0.8228	NS	1.1353	NS
Starling			0.6644	NS	0.6846	NS
Brambling			0.6978	NS		

Probability values are presented for the effects of tillage on between-plot distribution. Directions of associations are provided. Model goodness-of-fit figures give the ratio of residual deviance to degrees of freedom, a measure of the appropriateness of the binomial error structure (and hence the fitted model) to the data. Empty cells indicate where insufficient or sparse data meant models could not be fitted. Bold = significant.

may therefore have been largely influenced by goldfinches, this influence diminishing in 2004–2005 and 2005–2006 with the lower abundance of this species. Similarly, goldfinches were uncommon at Dióskál 2, and no association between granivores and CT was found at this site in any year.

The reduced total number of granivorous passerines and reduced proportion of goldfinches, in winters 2 and 3 could be a result of either of two factors. Firstly, the weather was substantially different between the 3 years, with much more snow cover in the second and third winters. As well as harsh weather potentially affecting the composition of the species assemblages present in the area, snow cover may have affected access to surface seeds for many species. Goldfinches particularly were observed to feed on adjacent weedy habitats more when access to the ground on the experimental plots was prevented by continuous snow cover. Second, the difference in CT methodology prior to spring maize in the second winter, with use of a cover crop in winter 2, may have also reduced access to seed resources (Butler et al., 2005; Wilson et al., 2005), thus rendering the CT plots less attractive to some species than in winter 1. This however, does not account for the similarity of results recorded in winter 3 with those in winter 2. This is more likely to be due to the increased snow cover in these winters. Thus, in a land-locked continental country such as Hungary, increased soil surface seed resources are only likely to be of benefit in milder winters, when access is not prevented by snow cover. In harder winters, the importance of non-cropped weedy areas is likely to increase. Therefore, adoption of methods like CT for increasing bird food will not completely compensate for the loss of marginal and weedy areas, which will still have an impact on bird survival at a time of year when food resources are critical. In this context, it is interesting that the 'Edge' term was only significant in models for one group in one winter. Whilst this was in the hardest, third winter, it was not for granivorous species, but for invertebrate feeders. This result may indicate that adjacent weedy areas could act as a source of mobile invertebrate food (Vickery et al., 2002), much as 'beetle banks' do in UK arable fields (MacLeod et al., 2004).

CT at this site is a relatively recently introduced tillage system, as it is likely to be throughout Eastern Europe. The extent to which bird associations with CT are long-lived is uncertain. The initial associations of granivorous passerines and skylarks with CT, presumably due to increased availability of weed and cereal seeds, may decline over time as the newly available soil seed bank becomes depleted.

The relationship between invertebrate feeding species and tillage is generally less clear. We have not demonstrated any link between such species and tillage in this study, with the exception of starlings in 2004–2005. It seems likely that this again was the result of relative abundance of different species, within a guild. Similar species-specific differences have been found on Hungarian grassland in relation to grazing intensity (Báldi et al., 2005). Whilst starlings were more abundant on CT plots at Dióskál 1, the guild of invertebrate feeders as a whole (which included starling) was not. This again suggests species differences in response to tillage, due to different feeding strategies, that are masked by grouping of these species. Additionally, the exceptionally large flock of 14,000 starlings recorded at Dióskál 2 in March 2006 were seen almost exclusively on two CT plots, with only two birds on the P plot between the two CT plots.

Acknowledgments

This work was part of the EU 'Life Environment' project 'SOWAP' (Soil and Water Protection, Project Number **LIFE03 ENV/UK/000617**), joint funded by the European Commission and Syngenta (http://www.sowap.org). We thank the Plótár family for access to their land and Anglian Water Plc. for provision of office facilities in the UK (RHF). Andy Evans, András Báldi, Jon Cole, Ceris Jones, Jane Rickson, Keith Chaney, Heidi Cunningham and an anonymous reviewer gave helpful comments on an earlier draft of the paper.

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