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Consequences of organic and non-organic farming practices for field, farm and landscape complexity.

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Abstract

This paper provides a detailed description and analysis of habitat and management differences between 89 pairs of organic and non-organic fields on 161 farms containing arable crops distributed throughout England. Data were derived at different scales ranging from field to landscape scale using a range of methods including: land manager questionnaires, habitat surveys and the use of large scale landscape datasets. Organic farms were situated in inherently more diverse landscape types, had smaller field sizes, higher, wider and less gappy hedgerows subject to less frequent management, used rotational practices including grass, were more likely to be mixed farms and did not use artificial fertilisers and pesticides.

Organic farms were associated with heterogeneous landscape types. However, even in such landscape types the organic farming system produced greater field and farm complexity than farms employing a non-organic system. The findings of the study point to the importance of organic farming systems for maintaining landscape and local complexity with consequent benefits for biodiversity in arable farming landscapes.
Key-words: Landscape complexity; habitat management; biodiversity restoration; farming system

1. Introduction

A number of studies have shown that organic systems may enhance species biodiversity over non-organic counterparts as a result of increased complexity or quality of landscape features from the field to the landscape scale e.g. for birds; (Chamberlain and Wilson 2000; Freemark and Kirk 2001), for plants; (Aude et al., 2003; Roschewitz et al., 2005a; Gibson et al., 2007; Boutin et al., 2008) and for invertebrates; (Schmidt et al., 2005; Rundlof & Smith 2006; Holzschuh et al., 2007). Other studies looking at biodiversity differences between organic and conventional systems have shown that complexity at the farm and landscape scale, independent of farming system, explained biodiversity differences between farms (Weibull et al., 2003; Clough et al., 2005; Purtauf et al., 2005). Recent work strongly suggests that for certain taxa, organic farming delivers fewer benefits when located within heterogeneous landscapes, with relatively large amounts of semi-natural vegetation, rather than simpler landscapes dominated by intensive farming (Roschewitz et al.,2005b; Schmidt et al., 2005; Tscharntke et al., 2005; Rundlof and Smith 2006; Holzschuh et al., 2007) although differences may still exist (Gibson et al., 2007).

The reviews on the impacts of organic farming on biodiversity (Shepherd et al., 2003; Hole et al., 2005) draw attention to the need for system-level studies that incorporate components of management practice (as required/encouraged by organic certification bodies) which may differ between organic and non-organic farming systems. The elements of management practice which may have important implications for biodiversity include both regulations defining organic practice, such as the prohibition of many chemical pesticides and inorganic fertilisers for organic farmers (Anon 2007) and indirect effects of those regulations, e.g. the use of grass-clover-leys for nutrient enrichment and weed suppression. Shepherd et al. (2003) indicated that, in addition to these management options, organic farmers also tend to have greater diversity of crop structure (Unwin and Smith 1995), under-sown crops (Altieri and Letourneau 1982) and lower stocking densities

In contrast to previous studies this study attempts to understand the nature of any relationships which may exist between farming system and field, farm and landscape complexity by investigating a large sample of paired organic and non-organic fields and farms with arable land. As the sample of organic farms included farms which had converted to organic farming at different times it was also possible to explore the impacts of longevity of organic practice on some of the measured variables. In this study no attempt was made to control for differences between organic and non-organic farming systems in any of the variables above, with farms being paired purely on location and covering the whole of England, thus allowing any differences in the above variables to be explored. The implications of the observed differences in field, farm and landscape complexity for the substantial differences in richness and abundance found for a range of taxa on these study farms, (almost all of which reached higher levels on the organic farms) (Fuller et al., 2005) are considered.

2. Methods

The study was based on a total of 88 non-organic and 73 organic farms over three cropping seasons between 2000 and 2004. Within these farms, landscape context and farm management practices centred on 30 pairs of target spring cereal fields (in 2000) and 59 pairs of target winter wheat fields (over two seasons 2002-2004). In order to cover as many farms as possible, on the majority of farms only one cereal field was studied, although due to the limited numbers of farms with organic cereals available during the period of the study both a spring and a winter field were examined on 16 organic and 1 non-organic farm. Each organic target field was paired with a target field on a different non-organic farm. Target fields were almost always surrounded by similarly managed fields managed by the same farmer. The vast majority of registered English organic farms growing cereal crops on holdings of more than 30 ha during the period of the study were included. Organic farmers were recruited through the two major UK registration bodies, The Soil Association and Organic Farmers and Growers on the basis of their listed crops including spring and winter cereals. Non-organic farms were recruited with the assistance of a UK cereal growers organisation (the Home Grown Cereals Authority). Non-organic paired fields contained comparable crop types growing in the same season and located as close as possible (min = 1km, max = 15km, mean = 7.4km and SD= 4.9km) but not adjacent to the organic target field. This was to prevent any overlap in study area impacting on the results.

Landscape complexity

Potential differences in the landscape context of organic and non-organic cereal growing areas in England at the 1km^2 scale were assessed using data from Land Cover Map 2000 integrated with CS2000 field survey data 2000 (Fuller et al., 2002; Firbank et al., 2003a; Howard and Bunce 1996). For each of the 'cereal growing' 1km^2 in England, data on the estimated percent coverage of the Improved Grassland, Arable and Horticultural and other grassland (Neutral, Calcareous and Acid) Broad Habitats (see Jackson 2000) were extracted.

The landscape context for each of the 89 organic fields used in the study (based on the 1km^2 in which each target field was located) was compared against the typical context for land within the cereal-growing region of England. This was done by contrasting the proportions of different Broad Habitats, (both individually and grouped by grassland types) and the Northing and Easting of each 1km^2 in which there was an organic target field with a bootstrapped estimated mean for a random sample of 1,000 cereal growing 1km^2 in England. A SAS program (SAS 1990) was designed to produce an output giving two P values indicating whether the bootstrapped estimated mean for 1000 random sample km^2 was significantly greater than or less than (at the 0.001 level) the estimated mean for the squares containing organic target fields.

The land cover dataset (see above) was also used to investigate differences between landscape level variables for paired organic and non-organic farms on a local scale (1-25km^2). Data on the %cover of individual and combined Broad Habitats in: a) the 1 km^2 containing the target field (target square), b) the 3x3 km^2 with the target square at its centre – the 9km^2 scale - and c) the 5x5 km^2 with the target square at its centre – the 25km^2 scale, were compared between organic and non-organic farms in each pair using Wilcoxon's paired tests.

Farm and field complexity

Habitat survey areas were defined which covered a target field and up to five surrounding fields (dependant on number of adjacent fields). This aspect of the study provided a measure of farm-scale complexity. Within this area all habitat patches were mapped at the 1:25,000 scale. Habitat patches included individual cropped fields, game strips, woods, ponds, grass margins, hedges etc. A hedge was defined as a single habitat patch unless its composition or structure changed significantly or the adjacent habitats changed. Habitat survey areas were visited on five occasions during one winter and any changes in the habitat patches e.g. crops grown across the winter were recorded. Data were compared using Wilcoxon's paired tests.

Field boundary surveys recorded base width and height and species composition of hedgerows surrounding target cereal fields on 80 of the 89 paired fields (sample size was dependent on availability of local habitat surveyors).

Farmer questionnaires developed in conjunction with colleagues at the Royal Agricultural College and Elm Farm Research Centre relating to each target field and farm involved in the study were completed by personal interview. Farmers were asked to provide information from both target fields and the whole farm including: sowing dates, crop management (including rotation), farm and field size, boundary management, extents of non-crop habitats, arable and non-arable land, duration of management, agri-environment (AE) agreements held (Defra 2001), duration of organic management and whether or not they actively managed for wildlife. Data from the questionnaires was interpreted with advice from an agronomist, e.g. the grouping of marginally differing rotations into agriculturally meaningful 'types' of rotation such as 'cereals with a break crop or set-aside', 'cereals with a ley' and 'continuous cereals'. A range of analyses were carried out to test for differences between organic and non-organic farms (these included Wilcoxon matched pair test, paired T-Test, Mann Whitney test and Chi square as detailed in the results section). Simple regression was used to investigate the impact of the period of time for which a field had been under organic management on field size and the proportions of arable and permanent pasture present on the farm.

3. Results

Landscape complexity

The 1km^2 in which target organic fields were located contained significantly greater proportions of improved grass (managed leys and permanent pasture) and significantly smaller proportions of other grass (non-improved, including set-aside) than the mean for the random sample of $1km^2$ in English cereal growing areas (Table 1). The mean Northing of organic farm squares was significantly less than the mean of the random sample of $1km^2$ in English cereal growing areas indicating that the target squares were to the south of the range of cereal growing areas in England (Table 1).

Both the 1 and $9km^2$ in which the organic target fields were located contained higher ratios of grassland to arable land and more non-crop habitat than their non-organic counterparts. There were no significant differences between the farm types for the Broad Habitat types and groupings at the $25km^2$ scale (Table 2).

Farm and field complexity

There were marked differences between the areas of particular habitats types on organic and non-organic farm pairs (either in terms of total area or as a proportion of the area surveyed) (Table 3). The density of linear features (hedges and boundaries) was higher on organic farms. Organic farms contained more grass habitats and non-organic farms contained more cereal and cropped habitat in the sampled area (Table 3).

Hedgerow height, width and base width were significantly higher on organic farms than on non-organic farms and numbers of trees and woody shrubs were also higher though not significantly (Table 4). There were significantly higher numbers of breaks and gaps in hedgerows surrounding non-organic fields (Table 4).

Data collected from the questionnaire confirmed that the sample of fields used in the study were representative of the farm types under study (i.e. managed according to normal farm practice and surrounded by fields managed similarly).

More organic than non-organic farms had land in agri-environment (AE) schemes (Table 5), but the target fields around which habitat surveys took place were equally likely to be in an AE scheme whether they were on an organic (n=28) or a non-organic (n=26) field. Fields were smaller on organic farms (mean organic 7.36ha, mean non-organic 10.65ha, paired T- test, $p<0.001$) but farm size (Table 5) and contiguity of farmland (70% organic, 77%% non-organic) did not differ between farm types. There were large differences between farm types in terms of spring cropping on target fields (on the 30 farm pairs growing spring cereals) with organic systems using a wider variety of crop type (Fig. 1). Non-organic farmers did not under-sow spring crops with a ley, but 40% of organic farmers did (Fig. 1).

Differences in cropping practices reflected differences in anticipated crop use with the majority of organic farmers growing spring crops for animal feed (73%) and the majority of non-organic farmers (55%) growing for malting. Use of winter cereals was more similar between farm types with the majority of organic and non-organic farmers growing winter wheat, 15% of organic growers chose triticale (as a better low/no input crop) in preference to winter wheat (Fig.1).

The results indicated that a range of significant differences in management practices existed between organic and non organic systems including, for example; 1) rotations – with organic systems including grass leys (92%), non-organic systems using rape/vegetables or set-aside as a break crop (87.5%) , 2) hedge management practices – with organic farmers less likely to manage annually (only 49% managed hedges round the target fields in the study year compared to 74% of non-organic farmers, see also Table 5), 3) sowing times – organic farmers sowed later for both winter and spring crops (Wilcoxon's matched pair test, $p<0.01$), 4) more frequent use of animals within the organic farming system (predominantly to graze off either leys or crops, see Table 5), 5) use of synthetic fertilisers on all but one non-organic field but not at all on organic fields, 6) use of synthetic pesticides (particularly herbicides at 95%) on all non-organic target fields and not at all on organic fields.

There were, however, no significant differences between farm types in terms of: 1) the proportions of permanent pasture and its' management, 2) area of woodland, 3) number of ponds, 4) number of non-crop habitats listed, 5) type of farm ownership (e.g. tenant, shared farm, owner), 6) changes in hedge numbers on the farm historically (40 years) and 7) whether farmers positively managed for wildlife.

The surveyed organic farms had been registered as organic for up to 20 years with 49% registered organic for less than 5 years and approximately half of these converted for one year or less. The majority of organic farms were fully organic (66%), but 14% contained non-organic land which was unlikely to be converted. There were significant relationships between the length of time a farm had been registered as organic and a number of variables including; field size - very variable on new organic farms but generally smaller on older organic farms (r^2=0.04, $f_{1,84}$ =4.36, $p<0.05$), % arable - lower on older organic farms (r^2=0.109, $f_{1,63}$ =8.80, $p<0.01$) and % permanent pasture – higher on older organic farms (r^2=0.123, $f_{1,64}$=10.09, $p<0.01$). All of these were influenced strongly by the small percentage of farms which had always been organically managed (6%).

4. Discussion

The study suggests that farm management practices result in greater complexity on organic farms at the scales investigated which may be associated with positive impacts of organic farming on biodiversity (Bengtsson et al., 2005) including those found for the farms in this study (see Fuller et al., 2005).

This study also revealed that organic cereal growing farms in England tend to be located in more heterogeneous landscapes towards the south of England characterised by extensive mixed farming compared to more northerly intensive arable areas where non-organic cereal growing is concentrated. Rundlof and Smith (2006) found similar differences between locations of organic and non-organic cereals-growing farms in Sweden.

The pairing of organic and non-organic farms on the basis of their proximity to one another ensured that the fact that organic farms tend to be located in heterogeneous landscapes did not account for the differences between systems shown here, i.e. the organic and non-organic farms within a pair were located within broadly the same landscape types as supported by comparisons at the 25km^2 scale. Results for the one and 9km^2 surrounding target fields and for habitat surveys indicated that even within similar relatively heterogeneous landscape types organic farms were characterised by higher landscape complexity than was found in their non-organic more arable dominated counterparts (see Gibson et al., 2007).

Supporting management data provided evidence that differences at the farm scale may result from the fact that organic farms incorporating cereals were more likely than their non-organic pair to be mixed farms with 'older' organic farms containing the lowest ratios of arable to permanent pasture. Additionally organic farmers incorporated grass-clover leys into their rotations and planted a wider variety of cereal types which were frequently under-sown with a ley. Greater complexity of both crop structure and field use at the landscape scale is likely to attract a broader range of potentially beneficial species because of the availability of a larger number of different habitat types as opposed to more uniform landscapes (Benton et al., 2003; Weibull et al*.,* 2003; Rundlof and Smith 2006; Clough et al., 2007; Oberg et al*.,* 2007). The presence of long-established permanent pasture may be particularly important as a permanent habitat for insects (Purtauf et al., 2005).

In addition to the complexity resulting from field use, non-crop habitats covered a greater extent in the locality of organic farms and on the farms themselves than on their non-organic counterparts in both the 1 and 9km^2 surrounding the target fields. Habitat surveys revealed that densities (length per unit area) of linear features, both hedges and boundaries, were higher on organic farms which correlated with the questionnaire finding that fields were smaller on organic farms. The presence of stock on organic farms encourages the maintenance of stock-proof hedges and this is reflected in the hedge information collected by habitat surveyors indicating that hedges on organic farms were higher, wider and less gappy than those on their non-organic counterparts.

The greater extent of non-crop habitat in the vicinity of organic farms is likely to be beneficial for biodiversity, e.g. Holzschuh et al. (2007) found that landscape heterogeneity and the availability of semi-natural nesting habitats resulted in higher bee diversity on farmland. Smaller field sizes and higher densities of hedges provide a high perimeter to area ratio which is correlated with small scale landscape complexity and higher species richness as found for plants, butterflies and carabids by Weibull et al. (2003). For organic farmers, the high perimeter to area ratio means that the benefits of the hedges extend over a greater area of the farmed land than would be the case if fields were larger. The condition of non-crop features is also important with well maintained continuous hedges providing important corridors for movement of species including small mammals (Gelling et al., 2007), nesting and feeding sites for birds (Chamberlain et al., 2001) as well refuges for plant and invertebrate species. Whilst organic certification bodies do not enforce rules on the creation or retention of non-crop features as an essential part of the farming system those practising organic agriculture in accordance with management guidelines such as those outlined in Lampkin (1990) recognise the importance of providing non-crop habitats for beneficial insects and other wildlife which help to control crop pests

The relationship between organic farming and agri-environment scheme participation was complex at the time of the study as the extent and management of farm habitats on organic farms may have made it easier for organic farms to enter into agri-environment agreements. The proportion of farms in the wider countryside with an agri-environment scheme at the time of the study was 14% (Defra census and agri-environment scheme data) contrasting with 45% of the non-organic study farms. This indicates that the non-organic farmers in this study were more 'wildlife friendly' than average which was possibly due to the recruitment process, i.e. farmers being asked to be a part of a biodiversity study may be more likely to agree if they are interested in biodiversity. The similarity of responses to the question of whether they managed for wildlife on their farms between organic and non-organic farmers also supported this. This tendency towards a more' wildlife friendly' farming style (see Schmitzberger et al., 2005), coupled to the fact that farms were located close to their pairs (i.e. in a similar landscape context at the coarse scale), makes the observed differences between the farm types more notable.

The most obvious difference between organic and non-organic farming is that organic farmers do not apply synthetic fertilisers or use non-organic pesticides

(Anon 2007; Romero et al., 2008). This results in secondary differences between the systems including timing of sowing and types of crop sown, for example, the use of triticale over wheat as a result of its lower nutrient demand. For most studies looking at organic farming effects on biodiversity these are the overriding factors differentiating organic farming from non-organic farming practices, see Gabriel et al. (2005) and Hole et al. (2005).

Organic farmers always sowed crops later than their conventional counterparts in order to avoid weed flushes. The difference was particularly marked for winter wheat where non-organic farmers were able to sow earlier through the use of pesticides in the early stages of crop growth. This ability to allow weeds to establish and yet restrict their impacts on crops through pesticide use enables non-organic farmers to allow natural regeneration on cereal stubbles which are a particularly attractive environment for birds (Gillings et al., 2005). Organic farmers choose to use fertility building crops on their set-aside land rather than leave it unmanaged (set-aside on non-organic farms is likely to have been recorded as ‘other grass’ for landscape context comparisons). Whilst both stubbles and set-aside have been shown to be beneficial to wildlife (Firbank et al., 2003b) it is open to debate as to whether the presence of naturally regenerating stubble or set-aside fields isolated within a relatively homogenous landscape at the small scale are better for biodiversity than a system which results in an inherently more heterogeneous and weedy landscape at that scale.

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Table legend

Table 1. Results of analysis comparing distributions of individual and grouped Broad Habitats in the 89 $1km^2$ in which organic farms were located and 1000 random samples of 89 $1km^2$ in the cereal producing areas of England. Significant results are indicated in **bold** type.

Table 2. Descriptive statistics and results of Wilcoxon's matched pair tests for comparison between landscape composition (using %cover of individual and combined Broad Habitats) of the 1, 9 and $25km^2$ in which the organic and non-organic target fields (n=89) were centred. Significant results are indicated in **bold** type, n.s. = non significant. N.B. other habitat types comprise a very small % cover in some squares; hence % cover does not equal 100%.

Table 3. Results of the comparison between habitats on organic and non-organic farms in the habitat survey areas. S.D. = standard deviation, n = no. of farm pairs, Variables showing significant differences between farm types (Wilcoxon tests) are shown in **bold** with level of significance indicated against the organic result thus:* p<0.05, **p<0.01, ***p<0.001.

Table 4. Descriptive statistics and Wilcoxon's matched pair tests for comparison between organic and non-organic farm types for the target field (n=80). Significant results are indicated in **bold** type, n.s. = non significant. The sign next to the Wilcoxon score indicates which farm type has the highest score; '+' = organic, '-' = non-organic.

Table 5. Summarised results from the farm management questionnaire. Information on variables where testing was inappropriate is included (org = organic farms, n-org = non organic farms).

Table 1. Results of analysis comparing distributions of individual and grouped Broad Habitats in the 89 1km^2 in which organic farms were located and 1000 random samples of 89 1km^2 in the cereal producing areas of England. Significant results are indicated in **bold** type.

Variable	Mean Organic squares	Mean Random sample squares	P greater	P less
Arable (%)	40.5	42.3	0.731	0.269
Improved grass (%)	**35.1**	24.4	**0.001**	0.999
Other grass (%)	4.3	11.0	0.999	**0.001**
Easting	437.2	441.0	0.648	0.352
Northing	232.6	278.01)	0.999	**0.001**

Table 2. Descriptive statistics and results of Wilcoxon's matched pair tests for comparison between landscape composition (using %cover of individual and combined Broad Habitats) of the 1, 9 and 25km^2 in which the organic and non-organic target fields (n=89) were centred. Significant results are indicated in **bold** type, n.s. = non significant. N.B. other habitat types comprise a very small % cover in some squares; hence % cover does not equal 100%.

		1km^2				9km^2				25km^2			
Broad Habitat Type or grouping	Farm type	Mean	Standard deviation	Wilcoxon	P value	Mean	Standard deviation	Wilcoxon	P value	Mean	Standard deviation	Wilcoxon	P value
Arable and Horticultural (a)	O	40.5	17.5	3.2	**<0.01**	42.0	15.7	2.7	**<0.01**	42.6	15.1	1.5	n.s.
	C	47.0	20.6			44.8	16.7			43.4	16.0		
All non-crop Broad Habitats	O	19.9	8.2	3.0	**<0.05**	20.5	6.7	2.8	**<0.01**	20.9	7.2	-1.7	n.s.
	C	17.1	9.3			19.2	8.0			20.2	8.7		
All grassland Broad Habitats (g)	O	39.4	15.6	2.6	**<0.01**	36.7	12.7	1.3	n.s.	35.6	11.5	-1.3	n.s.
	C	35.6	17.4			34.8	13.5			34.6	13.1		
Ratio arable: grass	O	1.6	1.8	3.6	**<0.001**	1.6	1.6	2.8	**<0.01**	1.58	1.44	1.8	n.s.
	C	2.4	2.8			1.8	1.8			1.69	1.60		

Table 3. Results of the comparison between habitats on organic and non-organic farms in the habitat survey areas. S.D. = standard deviation, n = no. of farm pairs, [1] Variables showing significant differences between farm types (Wilcoxon tests) are shown in **bold** with level of significance indicated against the organic result thus:* p<0.05, **p<0.01, ***p<0.001.

	Total length/area habitat				% contribution to total length/area habitat			
	Organic		Non-organic		Organic		Non-organic	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Linear features (km) n=48								
- Hedge	2.4	1.2	2.2	1.3	75.8	24.5	67.8	30.0
- Ditch	0.1	0.3	0.2	0.4	3.4	10.0	4.2	9.7
- Boundary [1]	**0.6***	0.8	**1.2**	1.5	20.8	23.1	28.0	29.4
Field habitats (ha) n=56								
- Bare ground	7.9	8.7	10.5	12.3	18.1	16.8	17.1	15.0
- Crop	**9.1*****	9.2	**21.1**	17.0	**22.5*****	19.8	**37.1**	22.6
- Grass	**12.9*****	10.1	**7.7**	8.7	**37.7*****	26.3	**17.2**	18.9
- Stubble	**6.7****	10.1	**11.3**	10.8	16.8	17.7	23.1	19.5
- Grassy margins	1.9	3.2	2.4	3.2	5.0	6.2	5.5	8.6
All habitats (ha) n=48								
- Bare ground	7.8	8.8	9.8	12.3	14.9	15.6	13.8	13.1
- Boundary [1]	0.1	0.1	0.1	0.2	0.2	0.4	0.2	0.2
- Crop	**4.0*****	6.1	**10.4**	13.1	**9.8***	17.5	**13.6**	14.7
- Ditch	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
- Grass	**9.2***	8.6	**6.4**	7.8	**20.3*****	15.4	**10.1**	11.5
- Hedge	0.8	0.5	0.7	0.5	**2.4**	3.2	**1.5***	1.3
- Grassy margin	2.2	3.4	2.6	3.1	4.7	5.6	5.1	7.5
- Pond	0.0	0.1	0.0	0.1	0.1	0.2	0.1	0.2
- Stubble	4.6	9.7	5.2	9.4	7.7	11.5	7.1	11.3
- Wood	0.5	0.9	0.5	1.2	1.0	1.8	0.7	1.3
- Cereal crop	**6.1*****	7.7	**16.7**	15.3	**11.7*****	12.3	**23.4**	17.7
- Cereal stubble	5.6	8.8	9.0	9.9	10.8	12.8	14.7	14.4
- Grazed grass	6.8	7.6	5.4	7.8	**15.9**	15.5	**7.7*****	10.0
- Root crop	**0.0****	0.2	**2.3**	6.0	**0.1****	0.5	**2.0**	4.9
Density linear features (km per ha)								
- Hedge	**0.1****	0.2	**0.1**	0.1				
- Boundary [1]	**0.2***	0.2	**0.1**	0.1				

[1] Boundary includes all boundary types (hedge, ditch & fences/walls). Results for variables which changed between visits (e.g. crop type) are presented as a mean figure for all farm visits. Numbers of farm pairs included in each analysis are given (these vary according to data collected by surveyors).

Table 4. Descriptive statistics and Wilcoxon's matched pair tests for comparison between organic and non-organic farm types for the target field (n=80). Significant results are indicated in **bold** type, n.s. = non significant. The sign next to the Wilcoxon score indicates which farm type has the highest score; '+' = organic, '-' = non-organic.

Habitat hedge features	Organic farm type		Non-organic farm type		Wilcoxon score	P value
	Mean	Standard deviation	Mean	Standard deviation		
Base height	0.2	0.2	0.3	0.2	32	n.s.
Base width	1.7	1.2	1.4	1.1	+511	**0.05**
Height	2.0	1.1	1.6	1.2	+482	**0.05**
Width	2.2	1.3	1.6	1.4	+619	**0.01**
No. breaks	3.0	3.6	4.3	4.7	-270	**0.05**
No. gaps	1.4	1.9	2.8	4.8	-257	**0.05**
No. of trees	25.1	30.4	23.0	30.1	255	n.s.
- No. live	22.3	26.5	18.2	19.1	249	n.s.
- No. dead	3.7	12.3	4.0	11.4	26	n.s.
No. woody tree/shrub species	5.7	2.7	5.3	3.0	196	n.s.

Table 5. Summarised results from the farm management questionnaire. Information on variables where testing was inappropriate is included (org = organic farms, n-org = non organic farms).

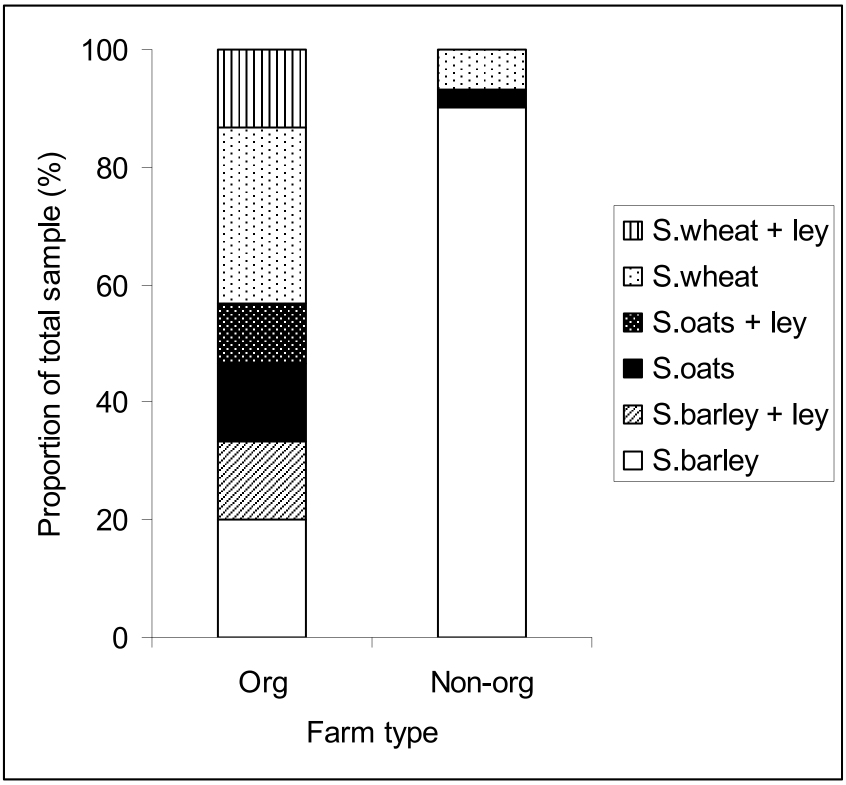
Field variable	n	Mean org	SD org	Mean n-org	SD n-org	Test used for comparison	Test statistic	P value	Notes
Farm size	89 pairs	246Ha	250	271Ha	280	Paired t-test	0.048	Non sig.	Farm size ranged between 30 and 1457Ha.
% arable land	158	58	28	70	24	Mann Whitney U	-2.4	<0.01	There was significantly less arable land on organic farms.
Agri-environment schemes on farms	158					Chi square			The proportion of organic farms in agri-environment schemes was higher than expected.
1. In schemes		46		37			3.95	<0.05	
2. Not in schemes		26		49			3.44	Non sig.	
Use of set-aside options	159					Chi square			The number of organic farms with no set-aside is higher than expected.
1. permanent		11		10			0.7	Non sig.	
2. rotational		41		49			0	Non sig.	
3. both		8		21			3.48	Non sig.	
4. none		14		5			5.27	<0.05	
Use of natural regeneration as a set-aside option	134					Chi square			Natural regeneration is significantly less likely to be used as an option by organic farmers.
1. yes		23		55			73.5	<0.0001	
2. no		37		19			10.4	<0.001	
Leys in system	158					Chi square			Leys within both systems were managed similarly, but were more common on organic farms.
1. yes		70		25			15.28	<0.0001	
2. no		3		60			61.40	<0.0001	
Livestock on farm	158					Chi square			Numbers of organic farms with livestock were higher than expected. A wider variety of livestock was found on organic farms including poultry, pigs, goats and deer. A few non-organic farms had pigs and horses.
1. yes		66		60			3.94	<0.05	
2. no		5		27					
3. beef		43		35			0.11	Non sig.	
4. sheep		40		17			7.04	<0.01	
5. dairy		23		23			0.08	Non sig.	

Field variable	n	No. org	No. n-org	Test used for comparison	Test statistic	P value	Notes
Livestock used on arable land	158			Chi square			More organic farmers than expected used their livestock on the arable land.
1. yes		56	35		9.98	<0.01	
2. no		15	52				
Frequency of hedge cutting	159			Chi square			Organic hedges were cut less often than expected
1. infrequent		68	48		21.03	<0.0001	
2. frequent		5	38		7.82	<0.01	
Hedge laying	159			Chi square			More organic farms than expected lay hedges.
1. yes		14	1		13.12	<0.01	

Figure legend

Fig.1. Cropping regimes on organic and non-organic farms. a) Spring cereals b) Winter cereals.

a) Spring cereals



b) Winter cereals

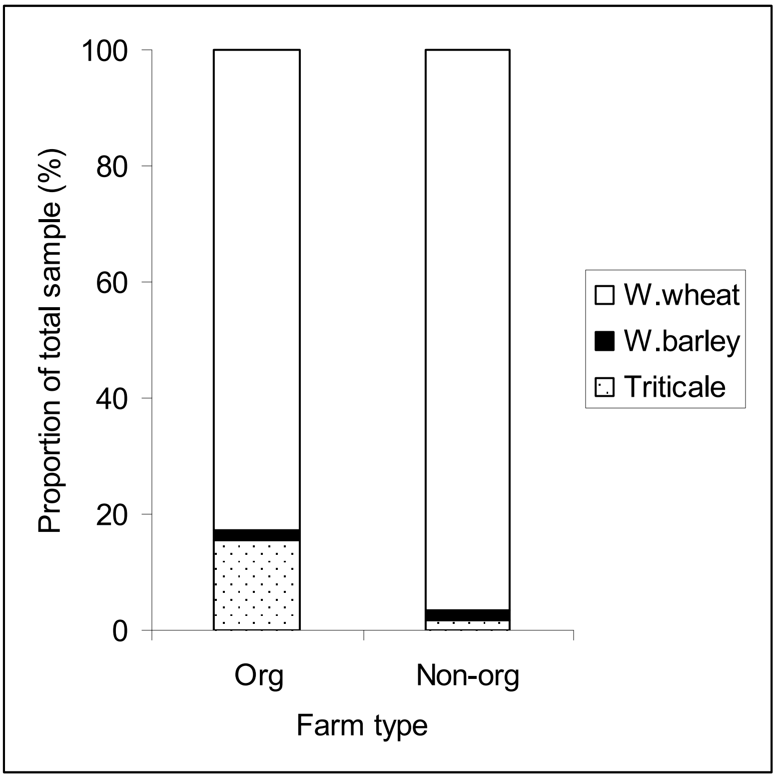


Fig.1. Cropping regimes on organic and non-organic farms.