

Changes in Abundance and Diversity of the Weed Seedbank in an Organic Field-Scale Vegetable System: from Conversion through the First Course of a Rotation

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ABSTRACT

Changes in the abundance and diversity of the weed seedbank was monitored over the course of conversion and first sequence of cash crops in an organic arable and vegetable rotation at HRI-Wellesbourne, UK. Three areas with different levels of fertility building and cropping length were investigated. There was an increase in viable weed seed numbers ranging from 54-495% in all areas at the end of one rotation. The rotations with the greatest proportion of cereals showed the highest increase in viable weed seed numbers. Two rotations maintained a constant (± 2 species) total weed species diversity over the course of the rotation. One rotation increased total weed diversity by eight species after the final crop with increases seen after the first and second cereal crops.

INTRODUCTION

The seedbank can be defined as 'the reserves of viable seeds present in the soil and on its surface' (Roberts, 1981). The weed seedbank is said to be the 'memory of the land' and its species abundance and diversity will reflect the previous cropping history (Buhler *et al.*, 1997). It will also contain the key to potential future weed problems. Weeds are seen as a major barrier for those considering conversion to organic farming (Davies *et al.*, 1997). Information and documentation on what happens to the weed seedbank during this change of farming system is required.

This paper presents the preliminary results of a six-year study investigating the changes in the weed seedbank during conversion from conventional arable to an organic system including field vegetables in the rotation. The weed seedbank of a field (Hunts Mill, Wellesbourne, Warwickshire, UK) has been monitored in three (0.8 ha) experimental areas (4-6) between 1996-2001, to establish if any of the practices or rotations used in conversion affect the composition of the weed seedbank. Results are presented in terms of changes in weed seed numbers abundance and diversity for an entire area at start and end of fertility building, then after the first, second and third crop. The results must be considered in the context that data have been summarized so there is no direct replication of rotations or statistical analysis and is therefore a descriptive document. Diversity data are presented in terms of the total weed seedbank which may mask/buffer the shorter term effects on the viable weed seedbank of the processes of conversion. This study is part of a DEFRA-funded project investigating 'Conversion to organic field vegetable production' (OF0126T). Further details are available from HDRA (2000).

MATERIALS AND METHODS

Three rotations are compared. The initial fertility building period and length of rotation varied; area 4, a 30-month grass/clover ley (5 years); area 5, an 18-month grass/clover ley (4 years) and area 6, a 6-month vetch crop (3 years) (Table 1). The three areas were further divided into six strips that have had slightly different rotations (e.g. area 4 1999, 3

strips were cropped with potatoes and 3 with cabbage) but for the purpose of this study data from a whole area have been combined. The basic rotations are given in Table 1.

Table 1. Rotations for areas 4, 5 and 6.

	1996	1997	1998	1999	2000	2001
Area 4	G/C ley			P/Ca	O/C/L	Sp. barley
Area 5	G/C ley		Sp. barley	O/C/L	Sp. barley	
Area 6	Vetch	Sp. barley	O/C/L	Sp. barley		

KEY: G/C= Grass/clover, P=Potatoes, Ca=Cabbage, O=Onions, C=Carrots, L=Leeks, all barley under sown with clover or grass/clover

Samples were taken at the start of conversion and after each crop. Each area (100.0 m x 80.0 m) was divided into six strips (16.7 m x 80.0 m). These strips were further sub-divided into quarters (16.7 m x 20.0 m) producing 24 samples per area. An auger (3 cm diameter) was used to take ten soils cores to a depth of 10 cm in each quarter. The soil was then air dried and analysed in 200 g sub sample portions using the wet sieving, flotation and filtering extraction methods as described by Roberts and Ricketts (1979). The numbers of 'apparently' viable and non-viable seeds per sub sample were identified and recorded.

RESULTS AND DISCUSSION

Weed species abundance in the soil seedbank

The average viable and total number of weed seeds per kg of dry soil is shown in Table 2. The table also shows the percentage that the viable weed seeds comprise of the total numbers. The baseline sample at the start of conversion and the sowing of the fertility building crops in August 1996 shows the total number of weeds to be very similar (range 106-109 per kg dry soil in the three areas).

Table 2. Average viable and total weed seed numbers per kg dry soil, and viable numbers expressed as a percentage of the total seeds at five sampling dates.

Area	Start of fertility build			End of fertility build			End of crop 1			End of crop 2			End of crop 3		
	Viable	Total	%	Viable	Total	%	Viable	Total	%	Viable	Total	%	Viable	Total	%
4	13	109	12	9	124	7	15	72	21	13	53	25	20	65	31
5	16	106	15	18	109	17	25	115	22	41	126	33	95	134	71
6	8	106	8	7	133	5	9	127	7	16	103	16	20	103	19

The rotation in area 4 was a 30-month grass/clover ley, two vegetable crops and a spring barley. There was a gradual increase in viable seed numbers (54% rise between start and end) and a decline in the total weed seedbank (40%) over the course of the 5 year rotation. Viable weed seed numbers declined during the grass clover ley and this the longest rotation had the smallest rise in viable seeds.

Area 5 had the highest number of viable weeds seeds (double that in area 6) from the start and throughout the rotation. Crop sequence was 18-month grass/clover ley, spring barley, vegetables and a second spring barley. The viable seed population rose considerably, by 495%, and the total by 27% between the start and end of the 4-year rotation. This is similar the findings of Albrecht and Sommer (1998) who recorded a

427% rise in total weeds germinated from the seedbank in conversion over a 3-year arable rotation. The main increase in seeds had been after the under-sown cereal crops. Work by Sjørsen (2001) in Norway had found the lowest seedbank levels after the first crop, a cereal after a 3-year ley. The main increase in this study was after the second cereal where bird damage in the crop had left open canopy areas and weeds, particularly *Matricaria* spp (mayweed), had flourished.

Area 6 had the shortest (3 years) and most intensive cropping sequence, a 6-month vetch, spring barley, vegetables, and spring barley showed a gradual increase in viable seeds (150% rise) and a similar level of total weed seed number (3% decline). This more frequently cultivated area had the potential to stimulate germination and decrease the weed seedbank although any weeds left to mature would soon counterbalance the seed reduction (Roberts, 1981). The fallow periods (16% over the rotation) may have increased viable seed shed (Zwerger *et al.*, 1993).

In all three rotations the fertility building phase kept weed seed numbers at a low level. The 30-month grass/clover ley (area 4) and the 6 month overwinter vetch (area 6) actually showed a decrease in viable seeds showing the importance of leys and dense suppressing cover crops on weeds. This is consistent with work by Younie *et al.* (2002) that found the higher the proportion of grass/clover ley in the rotation the lower the weed seedbank levels.

The rotations with the greatest proportions of cereals (5 and 6) had the highest increase in viable weed seeds; this was consistent with Albrecht and Sommer (1998) and Sjørsen (2001) and supports the general conclusion that increased proportions of annual cropping increase the weed seed bank.

Weed species diversity in the soil seedbank

Table 3 shows the total species diversity at intervals in the rotation. At the start of conversion total species diversity was 15 in area 4 and 6, and 13 in area 5. During the course of the rotation area 4 and 6 remained fairly stable (± 2 species). Area 5 ranged between 9-21 species dependent upon cropping, the greatest diversity recorded after the second cereal crop at the end of the rotation.

Table 3. Total weed species diversity in the seedbank at five sampling dates.

Area	Start of fertility build	End of fertility build	End of crop 1	End of crop 2	End of crop 3
4	15	13	14	16	14
5	13	12	19	9	21
6	15	14	13	15	15

Area 4 showed little change in species composition, *Chenopodium album* (fat hen) and *Viola arvensis* (pansy) occupied 85% or more of the seedbank through the rotation, dominance of fat hen actually increasing to 70% by the end. At the start, area 5 was dominated by fat hen and pansy (together 81% of the seedbank), at the final sample date the species were much more equally distributed, Mayweed now being the most abundant seed (30%) and six species making up 85%. In area 6, fat hen and *Papaver* spp. (poppy) comprised 85% of the seedbank, this dominance reduced to 66% by the end.

The seedbank in these areas is typical of those associated with cropped systems of Northern Europe, a few species dominating, and a wider range making up a low proportion (Roberts, 1981; Chauval *et al.*, 1989). Over the time period monitored there has been no specific shift in weed type. The grass clover phase has not favoured annual grass weeds as suggested by Roberts and Chancellor (1986) and Davies *et al.*, (1997). When only viable weed species diversity and separate rotation replications are considered a clearer pattern may emerge.

The greatest diversity and more equitable seedbank has been seen in area 5 as a consequence of a bird damaged barley crop allowing establishment and seed shed of a range of weed species.

CONCLUSIONS

A rise in viable weed seed numbers and the proportion of the weed seedbank occupied by viable weed seeds has been shown to increase following conversion to an organic arable/field vegetable system after one rotation. Cereal crops had greatest effect on viable seed increase, but also increased the diversity and reduced the dominance of the seedbank by individual weeds. Further analysis and statistical testing of the data set is required.

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