Fertility building strategies during the conversion period – assessment of performance in a stockless field vegetable rotation

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ABSTRACT

Nutrient off-takes, residue returns and nutrient inputs were measured during and after conversion from a conventional arable system to organic vegetables with cereals. This data was used to construct nutrient budgets to assess the effectiveness of contrasting fertility building strategies and various cropping regimes. The effect of placing the cereal crops in different places in the crop sequence was also considered.

Keywords: organic farming; conversion; soil fertility; nutrient budgeting

INTRODUCTION

The present lack of information and knowledge about organic farming systems, in particular relating to the conversion period, presents a major barrier for individual farmers to change from a conventional to an organic system. During the conversion period the farmer is faced with particular problems, different from those associated with established organic systems (HDRA 2000). Effective rotation design is particularly important; it is necessary to establish fertility building crops so that cash crops can be grown without synthetic fertilisers or large amounts of bought in manures. In stockless systems the fertility building period is particularly expensive because there is no direct economic return (apart from set aside payments). As well as providing nitrogen in the short term it may be necessary to address long standing soil problems e.g. low organic matter levels.

MATERIALS AND METHODS

The work was conducted at HRI Wellesbourne in Warwickshire (Hunts Mill field) on a sandy loam soil which had been used for conventional arable production. Conversion to organic farming began in 1995. For the purposes of cropping and monitoring the site was divided into six areas (each 0.8 ha); these were further divided into six strips. The initial fertility building crop was either a grass and red/white clover ley (30 or 18 months) or a six-month winter vetch. This was followed by a sequence of cash cropping which generally included high nitrogen demanding vegetables (potatoes or cabbages), low nitrogen demanding vegetables (onions, carrots or leeks) and cereals (usually spring barley) undersown with white clover which was allowed to overwinter after the cereal harvest. To date 25 unique cropping sequences have been grown. The site was stockless but green waste compost was applied at appropriate points in the rotation in accordance with the Code of Good Agricultural Practice. Crop yields from the whole plots were recorded and quadrat sampling was used to determine the productivity of the fertility building crops and the returns of unmarketable produce and unharvested debris; samples were analysed for their dry matter, N, P and K contents.

RESULTS

The nutrient off-takes in harvested crops were quite variable. For example Savoy cabbages removed between 28 and 73 kg N ha^{-1}. This was due mainly to variations in the harvested yield (which was seasonally dependant) rather than the nutrient content of the plant material. Expressing the values as a proportion of the fresh weight yields (Table 1) can reduce the variability in the data.

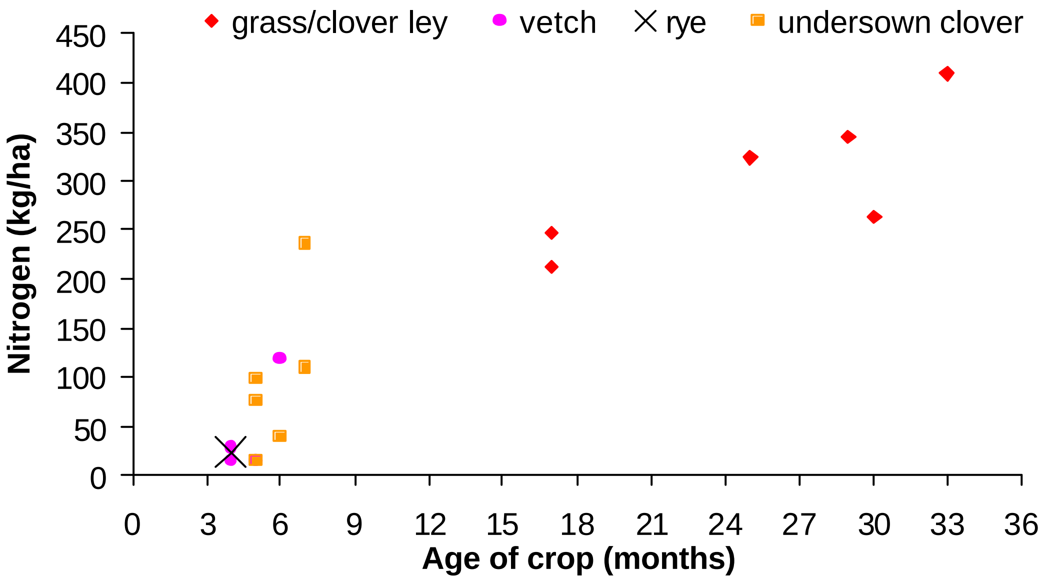
Table 1. A summary of crop nutrient off-takes at Hunts Mill. Values (in kg t^{-1} fresh weight yield) are the averages of crops grown between 1998 and 2001.

Crop	No. of crops	Nitrogen	Phosphorus	Potassium
Potatoes	10	2.4	0.7	5.0
Green cabbage	5	3.4	0.5	3.5
Savoy cabbage	4	4.4	0.7	4.5
Onions	10	2.1	0.4	2.1
Carrots	10	1.4	0.4	3.3
Leeks	10	2.6	0.4	3.4
Spring barley	31	12.7	3.0	4.8

The amount of nitrogen returned to the soil by debris from these crops ranged from 13 kg ha^{-1} (onions) to 84 kg ha^{-1} (cabbages). Brassicas generally produce large amounts of residues; the nitrogen these contain must be accounted for if it is to be effectively utilised by the following crop (Rahn *et al* 1992).

In the absence of animal manures the sustainability of cropping sequences depends on nitrogen from the fertility building crops. The green waste compost (which was applied mainly as a source of P and K and to add organic matter to the soil) contains between 1 and 2% nitrogen although this is in a very unavailable form (HDRA 2001). Figure 1 shows the relationship between the age of the various crops and the amount of nitrogen that was finally incorporated. In the case of the undersown white clover, age is taken as time spent as a dedicated fertility building crop after harvest of the cereal. The grass/clover leys clearly added more nitrogen to the soil than the other fertility building crops but they also occupied the ground for long periods of time. Although such crops add the most nitrogen to the system, several shorter-term fertility building crops may be even more productive.

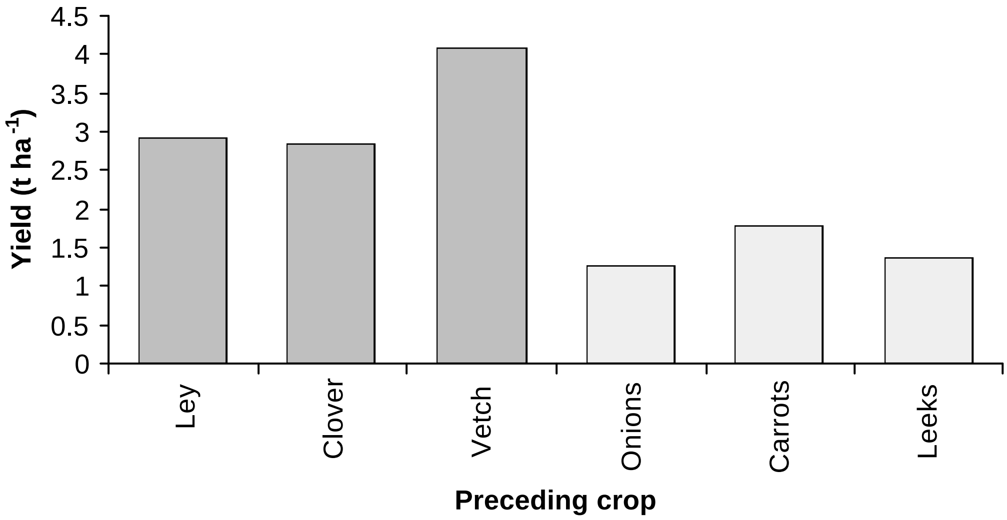
Figure 1. The effect of period of crop growth on N return from fertility building crops grown at Hunts Mill. Each point represents an individual crop.



Nutrient budgets were constructed for completed rotations. All the crop sequences showed a positive balance for nitrogen (+20 to +600kg ha^{-1}) but this was largely due to the application of compost nitrogen that will only become available slowly. Phosphorus balances ranged from –40 to +50kg ha^{-1} and potassium balances from –300 to +170kg ha^{-1}. Both P and K balances were more positive when fewer root crops (carrots and potatoes) had been grown.

An important question when designing rotations is the importance of the order in which crops are placed; the most nitrogen demanding crops are normally grown immediately after a fertility building period but other factors may influence this decision. Figure 2 shows the effect of preceding crop on the yield of spring barley. It is clear that higher yields were obtained after fertility building crops than after vegetables but this is not necessarily only due to crop nutrition. The onions, carrots and leeks were grown in beds and the wheelings could clearly be seen as lines of poor growth in the following cereal crop, reducing the overall yield. Measurement of soil hardness using a penetrometer suggested poor soil structure in these areas. Deciding on a crop sequence depends on many factors besides crop nutrition; one reason for placing the cereals after the vegetables was to allow re-establishment of the leys by undersowing, although this practice must be considered in each situation.

Figure 2. The effect of rotational position on the yield of spring barley. Each value is the mean of between one and four crops.



CONCLUSIONS

A diversity of fertility building approaches is available to the organic farmer and should be considered when planning rotations. Short-term winter green manures and clover leys may be very productive and are particularly suitable for stockless vegetable production systems. However, longer-term grass/clover leys may bring other benefits; they are an important means of adding organic matter to the soil and can have a part to play in controlling weeds, pests and diseases. Nutrient budgeting can be a valuable tool for assessing the theoretical sustainability of a system but there is a danger of placing too much emphasis on the chemical aspects of fertility. Factors such as poor soil structure can limit yields and it is important to also address these issues during the conversion period.

ACKNOWLEDGEMENTS

Thanks to DEFRA for providing funding and to the many individuals who collected the data over a six year period.

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From: Powell et al. (eds), *UK Organic Research 2002: Proceedings of the COR Conference, 26-28th March 2002, Aberystwyth*, pp. 125-128.