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Balancing fertility management and economics in organic field vegetable rotations.

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Abstract:
BACKGROUND: Organic field scale vegetables are among the most profitable enterprises in organic farming systems. They are also some of the most nutrient demanding crops and many organic arable systems with field-scale vegetables are stockless. Without livestock manure inputs, nutrient supply depends on fertility building crops, which generate only costs and no income. Different strategies of fertility management were compared on a central England research farm. Fertility management treatments consisted of different length of fertility building with green waste compost additions. Outputs and inputs in terms of nutrients and economics were monitored for 31 rotations during 1996-2002. RESULTS: The N, P and K rotational nutrient balances as well as the carbon inputs showed a negative relationship with rotational gross margins. Variable and allocated fixed costs of fertility building were low, between 2-5% of variable costs (0.5 - 2 £/ha for 1 kg N per ha supplied to the rotation). The intensity of vegetable cropping in these rotations was moderate (25-40% vegetable crops in the rotation) and balancing fertility management and economics was possible at this intensity without livestock manure or other permitted fertiliser additions. CONCLUSION: Completely stockless systems (in analogy may be called vegan) are possible in organic vegetable production without compromising on fertility or economics. However, for a higher vegetable cropping intensity (up to 90%) a more sophisticated mix of short-term fertility building and nitrogen trapping crops will be needed and such rotations may require further external addition of green waste or livestock manure.

Keywords: Organic vegetables, rotations, fertility building, nutrient management, nutrient balances, fertility costs, rotational gross margin

Introduction

Organic field scale vegetables have the potential to earn high returns per hectare. They are one of the most profitable enterprises in organic arable farming systems, with physical inputs being relatively low. However, labour and managerial inputs are high and so are the risks. Vegetables are also some of the most nutrient demanding crops grown. Many organic arable systems with field-scale vegetables are stockless, therefore in the absence of animal manure the sustainability of the cropping sequences depends on nitrogen from fertility building crops. Fertility building crops are also important to the organic rotation in terms of soil management, weed, pest and disease control. However, economically these periods generate only costs and no income, and therefore the right balance between fertility management and economics is important.

Material and Methods

Different strategies of fertility building and rotational design were monitored on research farms sites at Warwick-HRI, Wellesbourne in Warwickshire and Lincolnshire, and commercial organic farms in different regions of the UK (data not shown). This was done within the framework of Defra funded projects (OF0126T and OF0191) during 1996-2002. On the Wellesbourne site, a poorly structured sandy loam with 600 mm average annual rainfall, inputs and outputs in terms of nutrients and economics were measured. This included marketable yields, prices, variable costs (including fertility building and rotational costs not allocatable to any single crop in the rotation), allocatable fixed costs and the calculation of crop and rotational gross and net margins. Recording of variable and allocatable fixed costs was done by direct measurement *on-farm* were possible, or using published standardised figures (Nix, 2002). The research sites were farmed with similar patterns of treatments, but no structured replications, and as close to commercial practice as possible. Statistical analysis was done with Genstat 7.0, ANOVA. Student's t-test and regression coefficients are given were possible. Green waste compost was applied twice to all rotations with a rate of 30 t/ha fresh material, containing on average 45 kg N/ha/yr, 15 kg P/ha/yr and 60 kg K/ha/yr. More details on the agronomics of the site are given by Rayns et al. (2002). Nitrogen (N), phosphorus (P), and potassium (K) rotational nutrient budgets where gathered. The inputs considered for N, P, K balances were deposition and green waste compost additions. For the N balance, fixation was included; measuring quadrat samples of fertility building crops at incorporation (75% was considered as newly fixed). For N deposition, a standard figure of 20 kg N/ha/yr was used. N off-takes were measured as total nitrogen in dry weight of harvested vegetables and cereals. The outputs considered were leaching and crop off-take. The carbon inputs (C) were used as an indicator for organic matter additions and the C inputs considered were compost additions and residues from fertility building and cash crops. Three different strategies of initial fertility building were used converting the site from a conventional arable rotation to an organic field-scale vegetable production system. The strategies differed in the total fertility building time (30, 18 and 6 month), the length of the rotation (5, 4, 3 years) the percentage vegetable crops in the rotation (40%, 25%, 33%) the average year of vegetable growing (1999.0, 1998.5, 1998.0) and the type of vegetable crops (potatoes, cabbage, onions, carrots or leeks). There were six rotations in each strategy.

Results and Discussion

Rotational gross margins and fertility management

An analysis of the effects of increased initial fertility building periods (from 6 to 18 to 30 months) showed no significant relationship between length of initial fertility building and rotational gross margins. However, there was a significant relationship (R^2=0.98, $p<0.01$) with the percentage of vegetable grown (data not shown). A detailed regression analysis (Figure 1a,b) of the rotational gross margins from 31 different rotations with financial output, N, P, K C balances and N leaching, shows a significant positive relation with output (R^2=0.87, $p<0.01$) and an equally significant negative relation with N-balance (R^2=0.61, $p<0.01$). The relationships are also negative for the other fertility building parameters P balance, K balance and C input, however not significant; N leaching had no relationship (data not shown). The percentage vegetable-crops was low (25-40%) in the three strategies used and therefore, balancing fertility management and economics was possible. Even with the highest rotational gross margin of 4439 £/ha/yr the N balance was positive, the P balance neutral and the K balance moderately negative (-64 kg/ha/yr). If the permitted P and K fertilisers in organic systems or composted organic farmyard manure would be used, this could be adjusted if considered necessary.

Costs of fertility management

Costs of green waste compost and spreading were low (20-30 £/ha/yr) within a rotation, accounting for 0.5% of the average variable costs of a vegetable crop. Variable and allocated fixed costs of fertility building crops (seeds, sowing, power-harrow and plough, rolling, mowing, spring-tine were necessary) varied between 50 - 350 £/ha/yr, or 1 - 5% of the average variable costs of a vegetable crop. The costs were calculated for grass/clover ley, clover as main crop, clover undersown, vetch and grazing rye. In figure 1c, the total N supply of the N-fixing, fertility building crops (Rayns et al., 2002) is plotted against the age of the crop. With increasing age of the fertility building corps the total N supply was decreasing, however if these N supply data are plotted against the costs of these fertility building crops, a linear (R^2=0.44, $p<0.05$) relationship was found. Within a considerable variation, but independent of the different N-fixing fertility building crops studied (grass/clover ley, clover as main crop, clover undersown and vetch, excluding grazing rye), the costs are about 1 £/ha per 1 kg N/ha, with a slope of 0.96 (Figure 1d). In other words, as an example, an organic grower planning to supply 200 kg N/ha to a vegetable crop incurs costs of about 200 £/ha on fertility building cropping or about 3% of variable costs. Given the relationship in figure 1d, this may be achieved with the same costs using either one long, or more frequent shorter fertility building periods. Short-term fertility building makes it possible to fit in more vegetable crops in the rotation and reduce the need for longer fertility building periods. However, discussing this, fertility building crops were crops with low variation in gross margins (using set-aside payments) and hence low risk, while vegetable crops replacing longer-term fertility building can add considerable risk with the possibly of negative gross margins. Gross margins as low as –4000 £/ha were measured in some of the rotations monitored during this study.

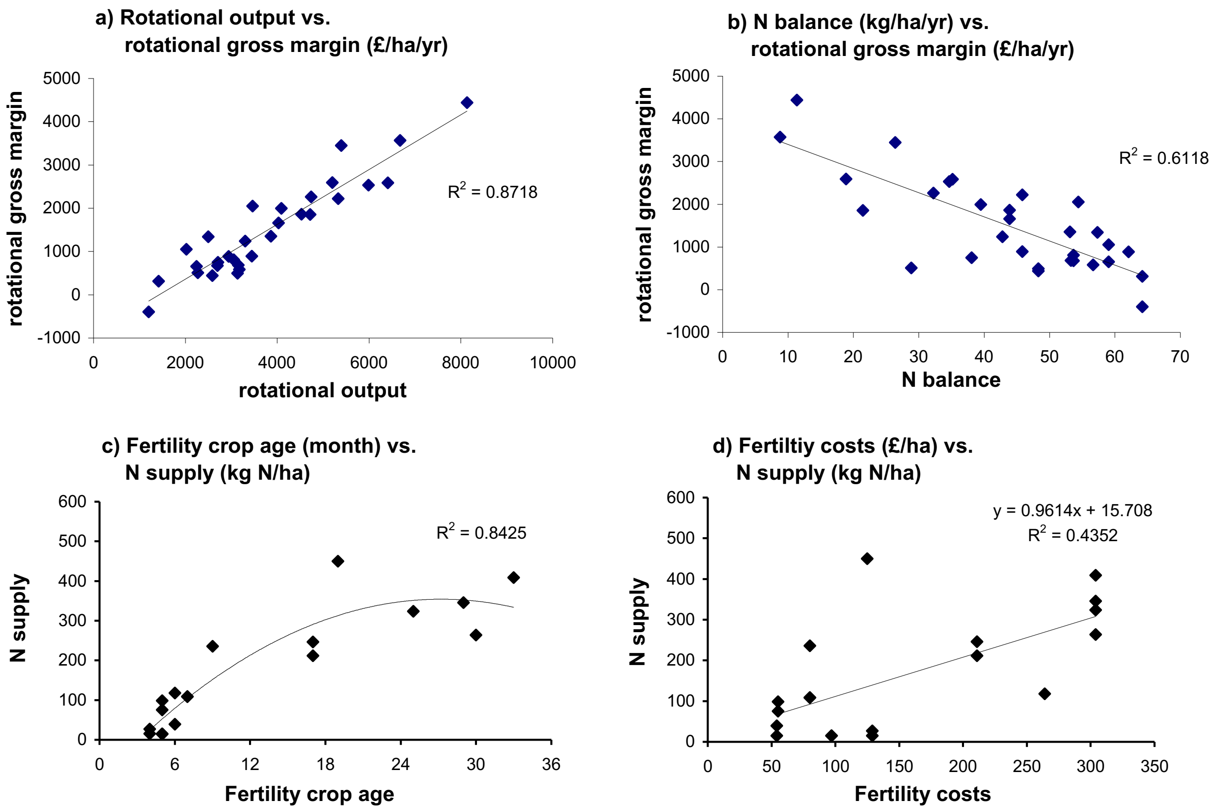

Figure 1a-d. Relationship of rotational gross margins with (a) economic output and (b) N-balance; relationship of N supply from fertility building crops with (c) age of the crop and (d) costs of production.

Finding the optimum balance

To find the optimum balance of fertility building and economics in vegetable rotations an increased percentage of vegetable cropping can be explored in the field and by using modelling software like EU-Rotate_N (Schmutz et al. 2004, 2006). For these higher vegetable percentages, a sophisticated mix of more short-term fertility building and nitrogen trapping crops will be needed. For the data shown, the measured average annual vegetable gross margin of 4000 £/ha can be used as a theoretical target value for the rotational gross margin. This modelling, however can only balance fertility and economics, there are other constraints like soil structure, weed pressure and pest and disease problems, restricting the percentage vegetables in a rotation.

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