**Vallis Veg Small Scale Horticultural Trial Proposal**

Chris Smaje

**Introduction**

This paper outlines a small experimental design for assessing three different methods of organic vegetable growing. The methods are:

1. No till, with the annual addition of compost derived mostly from beyond the growing area – a method popularised by Dowding (2007)
2. Grow bio-intensive, based on double dug beds and non-inversion tillage, with ‘compost crops’ grown in situ as part of the rotation – a method popularised by Jeavons (2012)
3. Green manuring with (minimum) tillage, involving a green manure ley within the rotation to build fertility which is then tilled in prior to cropping – a traditional practice which is comprehensively described in a modern horticultural context by Hall and Tolhurst (2006)

For convenience, I refer to these methods as the ‘Dowding’, ‘Jeavons’ and ‘Tolhurst’ methods hereafter.

The advantages of no till methods are increasingly well publicised. Comparisons between tillage and no till methods in conventional, large-scale agriculture in terms of yields, greenhouse gas emissions and other variables suggest a complex picture with results dependent on soil type, residue management, fertiliser regimen and so on (Rice and Smith, 1982; Sims et al, 1998; DEFRA, 2003). There appears to have been little comparative research on small commercial or domestic scale systems. Dowding (2012) has provided a recent informal analysis suggesting a yield advantage to no till vegetables, although it’s hard to infer statistical significance from his results. Organic methods require bulky composts or compost crops to be imported or grown in situ and incorporated, and this can require considerable space, or fossil fuel inputs, or labour inputs, or all three. Although compost from offsite is readily and cheaply available in the present economy, it has an ‘ecological opportunity cost’ (it could be used elsewhere, or not made at all). Growing methods that require bulky organic composts to be imported significant distances may also involve considerable hidden energy, labour or land use costs, and may not be sustainable in the long run. Thus in comparing different growing systems a whole lifecycle approach is preferable.

Another comparative dimension of interest is the performance of polycultures relative to monocultures. One context for this is the ‘inverse relationship’ between farm size and output: studies commonly show that small farms are more productive per unit area than larger ones (eg. Chayanov, 1926; Cornia, 1985; Barrett et al 2010). Labour input has sometimes been shown to be associated with the inverse relationship (ie. subsistence farmers on small plots are willing to invest relatively more of their time per unit area to achieve higher returns), as has ‘intensity of land use’, which is often measured simply in terms of the cropped/fallow ratio on the farm as a whole. But intensity of land use may also reflect more finely grained cropping choices such as bicropping or polycultures that better tap the total productive possibilities through ecological niche optimisation in ways that aren’t feasible on larger scales. This possibility doesn’t seem to have been much investigated, although van der Velden et al (2012) recently found no significant yield differences between specific 3-crop and 12-crop garden polycultures. Denison (2012) provides cautionary advice on the basis of evolutionary and crop ecology principles to suggest yield limitations to polycultures – some further thought may be required here.

**Outcome measures**

There are four key outcome indicators, as follows:

* yield per unit area
* yield per unit labour input
* yield per unit energy input
* soil quality

Each of these four indicators requires a little further explanation:

Yield per unit area: this is the most easily understood measure of ‘yield’, which is fairly self-explanatory. There are a few additional considerations, however:

* to compare each method fairly, the same crops should be grown in the same unit area quantities in each case. However, some growing methods may support closer spacing of the original plant stock than others on the basis of soil quality, a point emphasised by Jeavons in particular. It needs to be decided whether to allow planting density to vary accordingly, or whether to plant at the same spacings/density for each method.
* Similarly, crop yields in one particular trial plot may be adversely affected by pests or diseases. This could be regarded as a legitimate outcome in the comparison between methods (some methods promote stronger, healthier plants than others), or it could be regarded as a matter of luck (the pest/disease just happened to afflict the plants in that particular spot). The smaller the area planted, the harder it is to discount the influence of chance.
* There will inevitably be random variation within and between plots in crop yields year to year. It’s necessary to have some sense of whether the differences between plots are just the result of random variation, or whether they suggest a real difference resulting from the cultivation methods. Again, the smaller the area planted, and the smaller the yield differences, the harder it is to discount chance.
* the cropping areas themselves can be made equal, but methods requiring external compost input involve ‘ghost areas’ from where the compost is derived. These ought strictly to be included (just as the unproductive ‘fallow’ area in the green manure rotation is included).
* In order to assess polyculture yields, it’s necessary to grow the same crops as monocultures. Is the total yield of the polyculture any greater than the summed yield of the monocultures?

Yield per unit labour input: again, a fairly self-explanatory measure, based on kg yield per hour human labour going into its cultivation. It’s important as far as possible to take a whole lifecycle approach to labour. For example, the no till approach may save labour over the green manuring approach in direct cultivation but may involve additional labour in compost-making. Another consideration is the different possible measures of labour input: total labour, average labour and marginal labour. A method may show higher yields per hour of labour (average labour), but require such a large amount of labour input (total labour) as to seem unfeasible. Marginal labour productivity (the yield increase associated with an extra quantum of applied labour) is a particularly interesting question, but applies mostly to unit area yield increases in relation to marginal labour inputs at different scales of production/mechanisation. It is difficult to address this directly in the proposed experiment, but examining returns to marginal labour in the context of garden polycultures may prove illuminating.

Yield per unit energy input: this refers specifically to direct and indirect use of mechanical (fossil fuel) energy. Energy input in terms of human labour (muscle power) could conceivably be included, but this is already accounted for in the previous measure. The Tolhurst method uses mechanical energy directly (rotavating in green manure leys). The Dowding method uses it indirectly (producing and importing compost). The Jeavons method uses fossil energy only inasmuch as it may use compost sourced in the same way as the Dowding method, but it’s likely to use more muscle energy, which is accounted for in the previous measure. As mentioned previously, the logic of considering both direct and indirect energy use is that there is an ‘ecological opportunity cost’ of creating and importing external inputs such as compost. The energy inputs considered under this measure fall largely within the fertility-building strategies of the respective methods. There are other energy costs (such as seeds, tools, irrigation etc) but since these are largely the same across the three methods they can be discounted for comparative purposes.

Soil quality: ideally, the growing method should be adding to, or at least not subtracting from, the health of the soil. This can be examined by soil tests to determine basic soil indicators, including soil organic matter and soil microbe counts. Soil loss/erosion is a major concern in agriculture globally, and is compounded when annual crop cultivation leaves soils bare. Of the three methods examined, the Dowding method is likely to involve more bare soil than the others, and physical soil loss may be masked by the importation of compost. On the other hand, the humus building effects of compost addition may mitigate soil loss. It is difficult to address these issues quantitatively in this experiment. Qualitative visual inspection of the soil will be undertaken, but generally it will be assumed that there is no variation between the methods in soil loss.

**The Experimental Design**

The aim is to measure the outcomes mentioned above as effectively as possible and to eliminate as many extraneous influences as possible in order to compare the different methods as accurately as I can – though of course this is never entirely possible.

Given that this is essentially an unfunded, amateur experiment I have to be realistic about costs and inputs. My suggestion is to grow fairly small numbers and quantities of staple vegetable crops roughly along the lines of what I’d be likely to grow anyway as part of my domestic vegetable gardening. Any surplus can be sold through our veg box scheme (if we restart it...). On this basis, I’d propose the following rotations:

|  |  |  |  |
| --- | --- | --- | --- |
| Plot/Year | Jeavons | Tolhurst | Dowding |
| 1 | Carbon – calorie | Red clover | Potatoes |
| 2 | Carbon – calorie | Red clover | Cabbage |
| 3 | Carbon – calorie | Potatoes | Leeks – garlic – chard |
| 4 | Carbon – calorie | Cabbage (undersown to white clover) | Carrots – parsnips |
| 5 | Potatoes | Leeks – garlic – chard | Squash |
| 6 | Cabbage (undersown to white clover) | Carrots – parsnips | Drying Beans |
| 7 | Leeks – garlic – chard | Squash (undersown to red clover) |  |
| 8 | Carrots – parsnips | Drying beans (undersown to red clover) |  |
| 9 | Squash (undersown to red clover) |  |  |
| 10 | Drying beans (undersown to red clover) |  |  |

These rotations obviously won’t give an indicator of maximum potential yield for each method, but they should give a comparative indicator of relative yields between the three methods.

Jeavons (2012) recommends cropping areas of 60% ‘carbon-and-calorie crops (eg. grains)’, 30% ‘high-calorie root crops (eg. potatoes)’ and 10% vegetable crops. The rotation provided above is the closest possible approximation to retain complementarity with the other rotations. The proposed ‘carbon-calorie’ crops are mixes of red clover, lucerne, buckwheat, wheat, broad beans and amaranth.

This design then requires 24 plots. A further six plots are designated as follows:

* four control plots sown to ryegrass and regularly mown. These provide comparative baseline data for the soil test results. Located around the edges of the trial area, they will also hopefully act as buffer strips in relation to slug ingress, limiting the bias thus potentially introduced.
* one seedbed plot for leek and cabbage transplants
* one ‘polyculture plot’

The proposed layout for the plots is indicated in Figure 1. The dimensions of each plot are 1 x 10m.

*FIGURE 1: PLOT LAYOUT*



It’s proposed to locate the plots in the top field annexe at Vallis Veg, oriented N-S in an area 22x21m in size overall, which was tilled and cropped in 2010 and has been down to a fertility and humus building ley since (comprising cocksfoot, chicory and red clover). The soil is an alkaline silt loam over limestone. No particular heterogeneity across the cropping area is anticipated. Establishment will be initially by tractor close-topping of the ley and then:

* Dowding plots: mulching and adding a 50mm depth of compost annually in the autumn
* Tolhurst plots: rotavating
* Jeavons plots: rotavating followed by double digging

Since all methods require rotations and/or soil/fertility building programmes year on year, it’s not possible to randomise the three treatments across all plots. The proposed layout represents a version of a complete block design study, bearing this in mind.

The following main experimental design & analysis steps will be taken:

* transplants will be raised together and then randomised to the three treatments
* all sowing and transplanting across the three plots will be undertaken on the same day, and cultural practices will as far as possible be kept identical across the treatments
* plant spacings will be identical across the three treatments, at least in the initial year(s)
* pest problems will be monitored qualitatively across the treatments – the general approach where crop losses are heavy will be to replant crops whenever possible or exclude the yield from the analysis
* the ‘polyculture’ plot will comprise carrots, onions and chard, chosen for their complementarity and relative convenience as a cropping mix for commercial cropping. Yields will be compared to those from monocrop yields within the Dowding treatment only.
* a commercial soil test will be undertaken annually or biennially based on soil aggregated from the individual plots for each of the four treatments (Dowding; Jeavons; Tolhurst; control)
* labour input time for each plot/treatment will be recorded
* compost for the Dowding method will be made onsite using grass, wood chips and general site organic matter. The labour/energy inputs will be measured
* each year’s single or summed yield constitutes a data point. The data will be tested for significance using one-way analysis of variance (or possibly a non-parametric equivalent such as Kruskal-Wallis, depending on the distribution of the data). I will seek further statistical advice on this – it may take a while before there is sufficient data to infer any yield differences between the treatments. The overall distribution of the results may nevertheless be suggestive.

**References**

Barrett, Christopher et al (2010) ‘Reconsidering conventional explanations of the inverse productivity-size relationship’ *World Development*, 38, 1: 88-97.

Chayanov, A.V. (1926/1966) *The Theory of Peasant Economy*, Madison: University of Wisconsin Press.

Cornia, Giovanni (1985) ‘Farm size, land yields and the agricultural production function’ *World Development*, 13, 4: 513-34.

DEFRA (2003) *Development of economically & environmentally sustainable methods of C sequestration in agricultural soils* London: DEFRA.

Denison, R. Ford (2012) *Darwinian Agriculture*, Princeton: Princeton University Press.

Dowding, Charles (2007) *Organic Gardening The Natural No-Dig Way*, Dartington: Green Books.

Dowding, Charles (2012) ‘No dig experiments’ *Permaculture Magazine*, 74: 29-32.

Hall, Jenny and Tolhurst, Iain (2006) *Growing Green*, Altrincham: Vegan Organic Network.

Jeavons, John (2012) *How To Grow More Vegetables...* Berkeley: Ten Speed Press.

Rice, Charles and Smith, Scott (1982) ‘Denitrification in no-till and plowed soils’ *Soil Science Society of America Journal*, 46, 6: 1168-73.

Sims, Albert et al (1998) ‘Irrigated Corn Yield and Nitrogen Accumulation Response in a Comparison of No-till and Conventional Till: Tillage and Surface-Residue Variables’ *Agronomy Journal,* 90, 5, 630-7.

van der Velden, Naomi et al (2012) *Mixed Veg Production: Diversity and Efficiency in ‘Grow Your Own’ Food*, Leeds: Permaculture Association.