

No-till for growers: realising the promise of soil health in organic horticulture

Part 1 - Helping growers who want to make the change

We all know about the principles of soil health: cover soil, minimise disturbance, diversity in rotation or plantings, minimal chemical usage, living root in the ground as often as possible, they're endlessly repeated at agriculture conferences and on YouTube. But how do we make this a reality on our organic horticulture operations?

There are now working examples at every scale, from which we can extrapolate some principles of how to actually transition to soil health practices. What seems clear is that success stems from a rigorous application of the soil health principles as a whole, rather than a dogmatic adherence to one particular method or another. This results in increased awareness of every aspect of the growing system - constantly looking to eliminate or substitute an existing management practice with a better, more concurrent one. This comes by taking a cold hard look at all aspects of your management practices to find solutions that increase rather than deplete soil health.

Some might say my case studies are too few and far removed from the UK context to be relevant, but I believe this doesn't diminish their value. Especially as the success they report is relative to their local area and are therefore, in context. However, there are a number of key challenges: raising a tilth for easy speedy planting, weed control and the issue of mechanisation and potentially, the issue of how much land is under cultivation. As well as this there's the challenge of making high-labour operations pay, which they can, but the marketing needs to be right as well as the agronomy. The take home message is that it can be done and there are real production benefits for doing so. The following are some tips for achieving these aims, goals and outcomes.

How to transform your growing system and realise the spoils of soil health. The focus of the solutions given in this article centres round small-scale growing operations. But the principles apply equally under larger, mechanised operations and the technologies will vary with the scale.

Don't allow grasses in beds or paths

Although there is much good that grass can do for soil: protecting the soil over winter and helping to control perennial weeds, it is the one type of herbage for which deep or repeated cultivation is heavily indicated.

It's fairly common practice to keep the crop clean till mid season and then allow weeds and often grasses to establish and let them grow over winter, acting as a green manure. However since it's grass (a turf-forming perennial) cultivation is indicated when establishing the subsequent crop, and that cultivation will likely put the soil back to a worse state than before your short period of grass growth.

Although we are looking to provide overwinter cover, we're trying to eliminate cultivation passes wherever possible, so this is a no-brainer and a potential easy win, which leads on to the next topic.



Clean soil (where crop left-in) vs grass (where crop cleared)

Avoid perennials in fertility leys

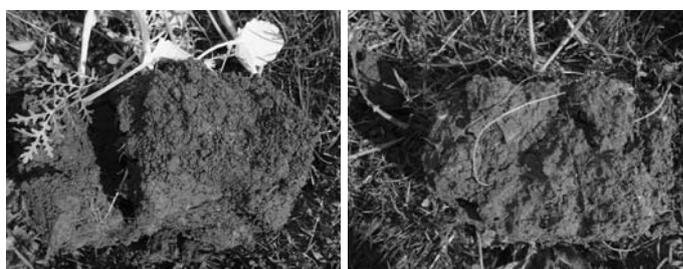
Like grass, clovers and other broadleaves used in ley sowings, all are perennials and as such have rather limited options for destruction. They also need frequent topping through the season, to keep them growing and to prevent seed shedding and a clover ley may need multiple passes to achieve a reliable kill.

It's not that grass leys aren't good for soil health, they are but this option is another example of where tillage is really the only destructive option for organic producers.

As well as this they require fairly long growth periods, at least a year, but ideally multiple years. It is generally agreed that you'll never have better land than when it's first out of grass - with the exception of wireworm, which may be another reason to consider alternatives.

There's nothing magical about grass or more specifically, perennial, turf forming grass when it comes to soil building. It's just that a diverse ley ticks all of the soil health boxes: covered soil, living root, diversity, no disturbance and ideal grazing.

However there are other routes to this end. We can mimic these situations with other management practices (see below) as well as species selection for green manures/leys, and achieve similar results. But in a cropping situation, unless you're actually also grazing as part of a mixed farming operation, then perennials in fallows are contra-indicated.



Cocktail cover crop (left) vs red clover (right)

Select diverse and annual species

In the case of organic horticulture, we are cropping annuals. So, when selecting fertility-building strategies we should select short-term, annual cover crop mixes as opposed to leys, annuals or biennials (with easy destruction options like sweet clover), cover crop mixes, with high diversity and high biomass, often called 'cocktail cover crops'. Allow these sowings to mature before terminating, ideally using non-inversion methods like rolling, crimper/rolling, mowing, trample grazing or sheeting down (this last option can also be used to kill an immature cover crop). This method will ensure 'grass like' soil building results, in a much shorter time frame, without the need for grass-type termination, ensuring that the good structure that was built under the cover crop is carried-over to the cash crop.

Diversity is key to realising the full potential of these plantings with better results than straight green manure sowings, with for example, red clover. This is probably one of the easiest crops when considering cover cropping.

Be honest about bare soil cover

We all think we're keeping tillage and bare soil to a minimum but how much is actually being achieved? These days, most growers are aware of the problems of tillage, but it's easy to overlook the extent of current practices on the ground.

In order to make a successful change, it's important to know what the current situation is, and measure against the baseline. It's helpful to address the following concerns: the length of time the beds are fallow; how long are the beds out of production; the dates between the first cultivation and first- (or last) plantings for a given bed or block.

It's important to remember that even short fallows equal no crop, no growth (no yield) and no soil building, as well as a loss of carbon, nutrients and structure. Without a living root, there's no energy source entering the soil and your fertility is literally evaporating into thin air - as the organisms literally consume their own 'houses' (or the organic matter they had fixed in the growth period).

Consider your answers to the following on an existing rotation: when the crop came out, when the cultivation passes were made and when the following crop was planted. The total of that time multiplied by the number of beds, gives a land area per unit of time that was bare. We're aiming towards a situation where soil isn't bare at all through the year, as a cumulative figure over a 3-5 year period.



Prepped bed - what's happening here and what's not happening?

Cover soil before planting

Where planting cannot be achieved immediately or soon after a cultivation pass, consider sheeting-down. This is not hard on a small scale and can be done with silage plastic or Mypex. Advance planning can help with sections of sheeting already cut to size for the beds or blocks, stored on reels or folded neatly for speedy application. It is also helpful to weight down the material so it doesn't blow away, with something like reusable sand bags.

This cover up will prevent weed seeds from germinating and possibly help to raise a tilth as the soil organisms digest and mineralise residues. When clearing beds, it's helpful if don't they lie fallow, even for a few days. Annual weeds like chickweed can establish in a very short period.



Bed prepped, sheeted down

Photos: Niels Corfield

Clear beds with care

When clearing beds, cover soil between following plantings or keep the crop in the ground. With a cabbage/broccoli crop leave the crop in the ground after harvesting the heads, the leaves will continue to suppress weeds, protect soil and the roots will continue to structure soil over winter by producing root exudates.

When clearing beds, even just a single row, sheet it down immediately, ensuring that it's weed-free for planting the following crop, improving the tilth by encouraging worm and microbe activity close to the soil surface. However bear in mind that in this period there will be a slow loss of organic matter (since no foods are entering the soil profile, due to the loss of root exudates). Remedy this by applying a top dressing of organic mulch, beneath the sheet, this will give the microbes a subsistence ration for this (fallow) period.

The minus six week fallow

When clearing beds, unless it is already under-sown, transplant or sow with cash crop or cover crop or sheet-down immediately.

We've all heard about '5 min fallows' - where the cover crop is drilled into the stubble of the previous crop. This is one of the main advantages of conventional no-till arable and it brings benefits by eliminating the time for ploughing-down the stubble and raising a seed-bed. But this leads to a break in root activity and root exudate production that will take between a few weeks and a month. During this period the now under-nourished soil organisms will begin to consume any accessible organic matter as an energy source for their



Pitney farm: overwinter brassica roots - best soil always around roots

metabolic processes and then go dormant, resulting in a loss of organic matter and slow loss of tilth. In horticulture, transplanting large or established seedlings directly after removing the previous crop will ensure a reduced drop in exudate production during the change over period and the follow-on crop will take up the slack much more quickly than standard plug plants. In this case we're talking approximately 2-3" cells or 6"+ tall plants. However, this approach will certainly require additional propagation capacity although the transplants will be more robust and, if properly husbanded, will have a much lower loss rate, and likely to be less nutrient stressed before going out.

Leave roots in place - roots build soil

When changing over from one crop to the next, the standard practice is to remove all crop residues, roots and all. This is disadvantageous for two reasons: firstly, the soil around the roots is always best for structure and tilth and the root zone is where the majority of the microbial activity takes place - this includes: nutrient release, biotic glue secretion, and aggregation. Even with the most vigorous shaking you're still going to end-up exporting most of that soil to the compost heap - not a bad place, but not where it is most needed.

Secondly, and most significantly, roots of established crop plants go on producing root exudates after termination, in fact most plants put out a mega pulse of exudates at the moment of termination/defoliation (this is why mob grazing is so good for the soil). At its dying gasp the plant gives up the stored sugars for the next generation. So, where coupled with relay-cropping, there is the absolute minimum drop in exudate production and with it the processes of soil aggregation and soil organic matter building remain almost continuous. As well as that, the residues from your crop roots will go to feed saprophytic organisms, which will end-up contributing to the pool of available nutrients.

That's not to say that this will be practical with every crop. Root crops for instance and some leaf crops, like chard, will want to regrow from a defoliation but if you keep hitting them and you've put in good transplants, this system does work very well. As with all these tips, it will need to be mastered and requires a no-till practice.



No-till planting, straight-in, no break.

Reconsider bed-forming

Formed beds are a common way to raise crops in market garden and horticultural operations, bringing yield benefits and isolating crops on wet sites. However, unless these beds are permanent they will have to be formed, and possibly flattened. This involves another tillage pass, undoing the good work that roots of crops or cover crops may have done in the preceding growth phase and involves both work and time. Some high efficiency, min-till farms have rejected formed beds on these grounds and established a precedent for a 'flat bed' system.

The other final consideration, as with all these tips, is weeds. Having a concave path cross-section means you need either specialist weed attachments for tractors or you'll need to spend more time hoeing and inevitably end up breaking down the side of the bed, which in due course forces a need for reforming. However, if you have or wish to have a permanent bed system then hand weeding is necessary. In this case, it is useful to optimise this practice with good quality knee pads or a lazy weeder system.

However, if your operation involves bed-forming, it is useful to include the location on the 'expanded rotation' chart, noting how frequently this work is carried out.

Survey & analyse weeding practices

This is a two-step process - identify and replace. Particularly in organic operations, weed control is one area where cultivation is 'forced' into the system. Depending on the technique, there is the possibility that it will have a measurable impact on soil health, serving to undo some of the good work that your fertility building practices have achieved.



Roots - let them keep on working

It's difficult to quantify the level of disturbance that a particular weeding technique causes. But we can possibly say that reducing the number of weeding passes may reduce the total amount of disturbance in any one season. To establish the baseline, it's important to know what weeding techniques are currently used and a gauge of how much disturbance they cause and also, when and where these weeding passes were carried-out. It's useful to record this information on the expanded rotation - at least for one season.

Concern over control is made up of two factors: weed growth/germination and control of established weeds. The first one being the main argument for going no-till, as tillage (or disturbance) actually stimulates weed germination, creating the need for cultivation - the definition of a vicious circle. However, the complete elimination of cultivation, for weeding and ground preparation (which is what no-till boils down to) may not be practical at a particular scale.

There is much that is subjective when it comes to assessing the impact of different weed control practices, but, it seems that setting-up an experiment, comparing a small number of practices side-by-side and using an empirical approach to evaluate the result, is useful. In the end, the goal is to move to a low-maintenance system and the essence of this is to eliminate a practice altogether, where possible, while retaining production.

Keep weeding till they're done

The first two years out of cultivation will be the worst for weed pressure, and more labour may need to be brought in or more areas sheeted-down for longer. But it's important not to give up because once the seed bank is exhausted the rate of germination will steadily decline. It will bottom-out at a low and manageable rate and at this point wind-blown seed will probably be the main vector for weed establishment, offering another site where covering the soil is important.

When establishing transplants, it is especially important for young plants to get their heads above the competition and having a light covering of mulch will help to suppress germination from the seed bank.

This is probably one of the biggest anxieties in a transition operation and shouldn't be underestimated. But once the decision has been made to go down this road, don't be tempted to resort to cultivation when it all looks bleak, as all that good work of resetting the seed bank will be undone. In this situation, sheeting-down areas that have 'got away' would be wise, and reviewing the amount of land under production, with a view to reducing the land area, either temporarily or even permanently. However hard that is, I think it is worth having all the options on the table when attempting to deliver the soil health principles on the ground.



Down Farm: intercropping & catch-cropping

Fill-in between wide-spaced crops

Don't let that space between your newly-planted brassicas go to waste. Intercropping is a long-established practice with the benefits with regards to weed control emphasised most and other factors downplayed. It was considered that there were potential antagonisms with the main crop and the belief that this type of practice would put more demands on the soil. However, the reality is the opposite, so long as we're adhering to the other soil health principles. The extra diversity of crops encourages root exudates, supporting a diversity of soil organisms (particularly significant in the case of brassicas, as they typically don't associate with mycorrhizal fungi). Therefore, through the loss of access to foods from host plants, a monocrop of brassicas force the mycorrhizae into dormancy or death. So, if you're catch-cropping, with fast-growing species of plants that are not brassicas, you'll be helping to keep those fungi established and providing longer periods of active root exudation into the soil.

Coupled with this, these fast-growing plants will put out a low canopy that will cover and protect the soil from evaporation and damage from rain splash, thereby helping to maintain that all-important surface tilth, while suppressing weeds.

Plants for this system will typically be lettuces, radishes or other short-season salads. If we want to optimise this approach we will want to be transplanting and would thus need sufficient propagation capacity (and introduce an extra line in our cropping plan - this will ensure these additional crops are produced and are ready for transplanting with the main crops).

Full-term combinations of cash crops may also be indicated, but either way the goal is to have a living root in the ground as long as possible while attempting to have diversity of plantings.

Reach for the crutches

Young plants planted into new no-till soils will lack necessary support, so don't try to go cold-turkey or ignore traditional plant growth aids. Organic materials can be put to use to ensure good results, without being beholden to high volume inputs. Young plants benefit from access to nutrients, if they are to get away and out-compete weeds.

In this case, we can look at compost as a starter fertiliser, (albeit a very good, organic one), about 1cm or 1/4" of compost applied at planting. The organic matter in the compost will also feed free-living saprophytic organisms that will help to liberate more nutrients into the surface zone of the soil. They may even help to create something of a 'biological tilth' through their activity, thus helping in future transplanting operations.

That said, though compost has many benefits, the organic matter will not contribute to stable soil organic matter or humus. This will be returned to the atmosphere through metabolism and digestion though the CO₂ enriched atmosphere around the soil surface will assist plant growth (as most of their stomata are on the underside of their leaves). Contrary to some advice, I believe that the application of the compost at planting is the most timely and effective point in the rotation. Although there's a valid argument that it will be wasted and not utilised, this is the point that the plants need it most and also the point when the microbes most need a boost (since there will be a pronounced drop in root exudate production).

I see no reason why un-rotted mulch materials, like woodchip might also work for this purpose although the nutrient release pattern will probably be much slower. Also, composted woodchip, possibly year old material that may have been turned a few times, will make excellent compost for top-dressing new plantings. Having a ready supply of compost or other mulch materials will always stand you in good stead

Raise a tilth by hand

There's no doubt that transplanting into soil with a good tilth is much faster and more pleasant than where the tilth is poor. Use broad forks or other non-inversion methods to loosen soil for speedy planting.

There are two types of tilth - 'mechanical' typically created through some kind of tillage and 'biological' the kind of natural crumb structure developed in good organic soil. This is found around the roots of healthy plants, either crop or cover crop. This structure is resistant to weathering, degradation and will sustain. The trouble with mechanical tilth raised by tillage, is that although the seed bed could be worked up nicely and sufficient for planting, it doesn't last more than a few weeks or days before settling



Elephant garlic mulched soil



Elephant Garlic crop: unmulched (left) vs mulched (right)

Photos Niels Corfield

back into a packed, consolidated and homogeneous structure with little pore space. If mechanical tillage is practiced, you will be going backwards, steadily losing structure and fertility every time the soil is prepared for planting. The trouble is, that the tillage triggers the digestion of soil organic matter by specific organisms and whilst this can boost yield, it contributes to a net loss in this matter and in tilth/aggregation.

In the transition phase, to facilitate efficient planting (as biological tilth is developing) it's an idea to find a means of loosening surface soil layers. On a small-scale the most heavily indicated tool is a broad fork (a large two-handed fork) and this can be used to loosen soil prior to planting, once or twice per year. Other methods include sheeting-down or mulching (see pic below). In this case, growers have reported soil conditions suitable for direct planting, weed-free and friable. The trick is retaining this structure going into the next crop.

Finally, the default option and probably least appealing is to just live with the heavier conditions associated with unworked soil and accept that planting will be more work and take longer. There is the reassurance of knowing that each year as the soil remains undisturbed, the surface tilth will get better particularly when combined with other soil health practices.

Conclusion

I am acutely aware that advice like this can seem somewhat glib or just impractical. That said, I feel there are some real opportunities for growers at any scale in the UK. I believe that a steady and on-going application of the soil health principles will lead to cumulative gains over time.

I also understand that many of you know this stuff already, and therefore know "what you need to be doing" but just don't have the time, man power, or the energy to implement these changes. Even if just taking the basic steps like: avoid perennials, sheeting down as you clear beds etc. I think there will be gains to be had that can be built-on over time

Niels Corfield

Part 2 of this article in the Summer OG will include the implementation of a new cropping system, analysing the rotation and many other topics connected with no-till for organic growers.