Organic Rotations - Chris Alenson Apr '15

'Can mankind regulate its affairs so that its chief possession – the fertility of the soil – is preserved? On the answer to this question the future of civilization depends" - Sir Albert Howard, An agricultural testament, 1943

Organic practitioners have always regarded soil management as one of the basic tenants of organic farming. Sir Albert Howard's words of wisdom points to soil fertility as the number one objective of this form of agriculture. In natural systems, biological cycles of life, death and decay operate to restore the soil's health. It is this Law of Return that guides organic farmers to optimise their soil's biological life to ensure optimum nutrition for the plants and crops grown. The conventional farming strategy of supplying plant nutrients through off-farm synthetic inputs illustrates the competing differences between the two nutrient supply paradigms where biological processes actively recycle organic wastes and solubilise soil minerals in the organic/sustainable approach.

Organic growers utilise several strategies to ensure crop production. One of the key strategies is crop rotation. It has been argued that nature does not rotate crops in either a grass climax system or in a bio-diverse forest system so why should our farmers need to. However it is obvious that nature abides by the Law of Return where organic waste products cover the soil surface where through active biology nutrients are continually recycled and the fertility bank is enhanced. A balanced rotation seeks to mimic the organic matter restoring systems of nature while producing economically viable crops.

The Principle of Rotations

Crop rotations are a carefully planned sequence of different crops that supply nutrients, organic matter, build disease suppressive soils and minimise weed incursions. The strategies of the rotation have to be carefully managed within the constraints of the environment in which it operates while ensuring economic profitability.

An example of early crop rotations in Britain was the three course rotation of autumn corn, spring corn and fallow which was adopted for well over 1,500 years. The Norfolk four course rotation took the form of roots, barley, seed and wheat.

It is essential to understand the role that rotations play in underpinning the fertility building cycle so important in achieving a sustainable system of agriculture. A good rotation is the foundation on which a successful organic system is based.

Continuous cropping without resting the ground will result in difficulties. These may include a decline in soil nutrients, imbalance in soil pH, a build-up of soil pathogens, a decline in soil structure and quite possibly land degradation in the form of wind and water erosion and the introduction of salinity problems.

Dr Arden Anderson sums up the importance of managing all aspects of soil fertility when he states, "If *a farmer chooses to create a soil environment that is most conducive to pathogenic microbes such as fusarium, verticillium wilt, parasitic nematodes, and mosaic viruses, he need only reduce the soil oxygen level, degrade humus, destroy soil structure and maintain a continuous toxicity level; we will then have the perfect soil environment for such pathogens."*

The organic rotation should have a balance between ***fertility building crops*** (grass or clover in pastures, legumes and a green manures in horticulture), which provide good quantities of root biomass for earthworms and micro-organisms, and ***exploitive crops*** (cereals, canola, corn, brassicas).

Crops that have natural weed germination inhibitors such as rye, sorghum and mustard may also be used in a rotation design.

The rotation design should cover nitrogen needs through the use of legumes and green manure crops. Organic matter improvement might be enhanced through deep-rooting pasture species, legumes, mature green manure crops, stubble or compost. Crops which are susceptible to weeds can follow weed-suppressing crops such as rye and sorghum. The rotation must also produce sufficient feed for livestock.

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Planting a diverse range of crops through each rotation should be effective in reducing plant pathogens and in preventing insect populations from becoming established.

In recent years researchers have found that planting specific varieties of Brassica can protect against a range of pathogens. CSIRO researchers Mathieson and Kirkegaard (1998) found that volatile compounds emanating from Brassica root pieces indeed suppressed the growth of the cereal take-all fungus (Gaeumannomyces graminis) in vitro, and volatiles from root, shoot and seed meal tissues of canola and Indian mustard suppressed the mycelial growth of five soil-borne cereal pathogens. This gave rise to the term 'biofumigation' to describe the phenomenon.
Other factors that need to be considered when planning the rotation are whether there is a market for the crops planned in the rotation and if they are suitable for the climate and soil type.
Rotations can be used to promote a larger, more diverse web of organisms. Different crops support different groups of soil organisms. Cereals tend to support fungi, whilst legumes support bacteria. Mycorrhiza tends to decrease when a fallow or non-mycorrhizal crop (such as canola, lupin and mustard) is incorporated in a rotation.
Rotations can also be used to encourage the disease- and pest-suppressing abilities of the soil foodweb. 'Take all' and cereal cyst nematode can be controlled in this way.

Lampkin, (1990) documents the following guidelines as essential to follow:

- *Deep rooting crops should follow shallow rooting crops, helping to keep the soil structure open and assisting drainage*
- *Alternate between crops with high and low root biomass – high root biomass provides soil organisms, particularly earthworms, with material to live on.*
- *Nitrogen fixing crops should alternate with nitrogen demanding crops – ideally it should be possible to meet all the farm's nitrogen requirements from within the system.*
- *Wherever possible, catch crops, green manures and under sowing techniques should be used to keep the soil covered as much as possible, protecting it from erosion risks and reducing nutrient leaching, particularly in winter.*
- *Crops which develop slowly and are therefore susceptible to weeds (perhaps onions) should follow weed suppressing crops.*
- *Where a risk of disease or soil borne pest problems exists (clubroot on brassicas) potential host crops should have appropriate time intervals before planting again*
- *Use a variety and crop mixtures where possible*

Lampkin makes the point that the rotation should also take into account the suitability of crops to the soil and climate, a balance between soil building and cash crops, seasonal labour requirements and cultivation requirements.

Green manure

Green manures play an important role in the rotation process. Green manuring is the practice of enriching the soil by the addition of undecomposed plant matter either grown on site or brought in from outside the farm. It has become an essential part of rotation design for organic farmers and should be considered as a worthy soil restoring practice for conventional farmers. They are a prime source of nitrogen, organic matter, supply forage for stock and reduce weed seed banks. Much of the applied organic matter is described as labile carbon which is more easily cycled thus supplying valuable plant nutrients.
Green manures grown to maturity supply the soil with valuable organic matter while when incorporated at an earlier stage supply the crop with easily assimilated plant nutrients. This addition of organic matter improves soil structure while some varieties will improve soil aeration at depth. The green manure crop itself increases the availability and cycling of important plant nutrients and stimulates and enhances the activity of soil microorganisms.

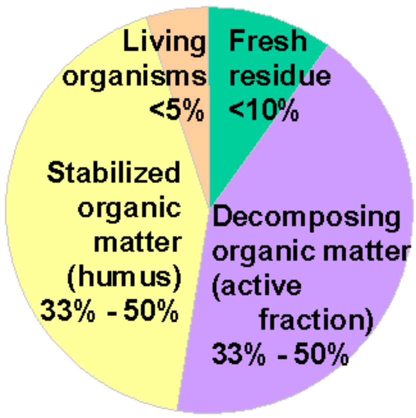

Diagram illustrating the different pools of soil organic matter

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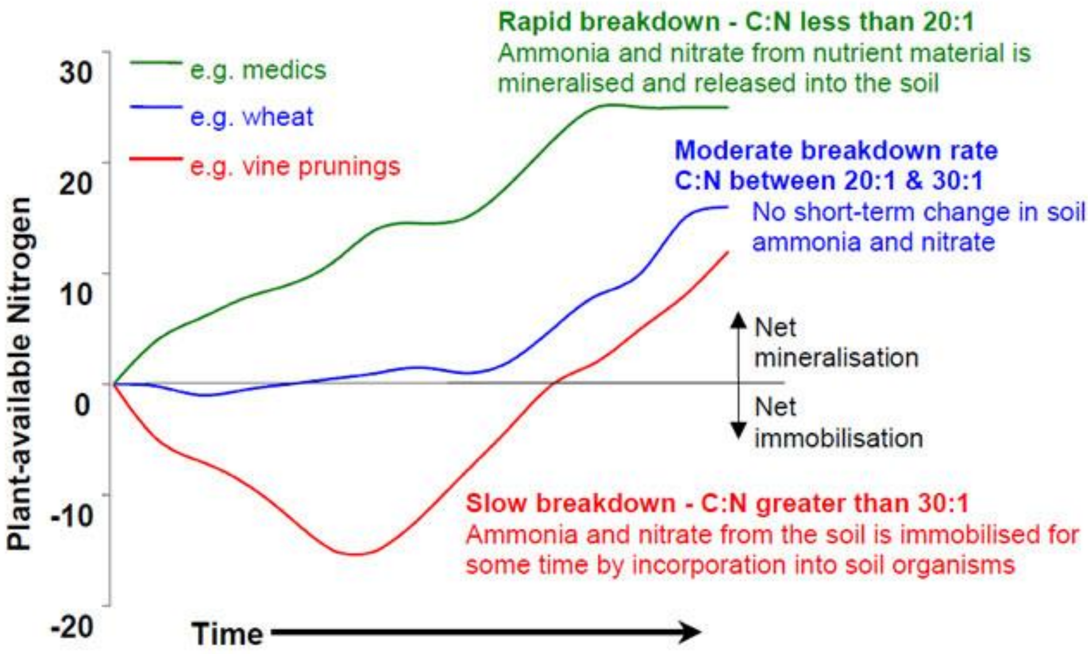
The addition of any organic material to the soil must be done in full knowledge of the implications on soil nitrogen supplies. The basis of this understanding is the carbon nitrogen ratio (C/N). All living material has a C/N ratio meaning that for example grass clippings has about 14 parts carbon to 1 part nitrogen, a ratio of 14/1. This is a ratio that demonstrates sufficient nitrogen for decomposition to take place. The wider this ratio, i.e. 350/1 (perhaps sawdust), the more nitrogen is required for this decomposition to take place. The addition of a high nitrogen source such as poultry manure would be required to ensure this process takes place. The following diagram illustrates the effect on the soil of incorporating organic matter with differing C/N ratios.



The table below illustrates the potential amounts of organic matter and nutrients that green manure crops can add to the soil system. Data is sourced from Elm Farm, UK so quantities may vary in Australian conditions.

CROP	Production t/ha	Production t/ha	Production t/ha	Production Kg/ha	Production Kg/ha	Production Kg/ha	Production Kg/ha	Production Kg/ha
	Green mass	Dry matter	Organic matter	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium
Rape	32.6	3.3	2.9	84	15.7	100.8	50	4.5
White mustard	17.5	2.2	1.9	61	9.6	67	36	4.5
Radish	20.1	2.5	2	96	11.2	84	40	6
White lupin	25.1	3.4	2.8	95	16.8	75	40	7
Vetch	20.1	2.8	2.3	102	13.4	67	35	4
Oats + vetch	32.6	3.9	3.4	101	15.7	100.8	40	6

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Demonstrating Sustainable FARM PRACTICES

Disease suppressive soils

A disease suppressive soil is simply one that indicates a level of disease in plants that is less than that found in plants in other soils, assuming similar growing conditions. They are characterised by a low level of disease even though that pathogen and a susceptible host exist in that environment. It should be noted that most soils can contain disease suppressive organisms but vary in the population size and effectiveness.

Researchers have found that this phenomenon is most likely attributable to a community of microbial organisms.

Suppressiveness is linked to the types and numbers of soil organisms, fertility level, and nature of the soil itself (drainage and texture). The mechanisms by which disease organisms are suppressed in these soils include induced resistance, direct parasitism (one organism consuming another), nutrient competition, and direct inhibition through antibiotics secreted by beneficial organisms (Sullivan, 2004).

The type of rotation and the additions of organic matter to the soil either through compost, crop residues, or green manures have been shown to affect the severity of soil borne pathogens. A number of researchers have noted decreased disease problems in organically managed soils. Importantly the physical condition of the soil (pore structure), chemistry (pH) also play a significant role in providing an environment conducive to the development of suppressive soil micro-organisms.

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