SOIL MANAGEMENT IN ORGANIC FRUIT GROWING

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Conversion into organic

In the EU-standards you will find a period of three years for converting your orchard from conventional into organic. But conversion of your way of thinking about the orchard system and conversion of your root system and soil will take double time. The focus must change from curative to preventive. Production, growth regulation, fertilisation, undergrowth, weed control and water management all come together in the overall soil management.

In organic agriculture there is no consultant any more who prescribes to you what, when and how much to fertilise all your orchards. Organic fruit growers are invited to look with one eye in the soil and the other eye at their trees and decide for each field what is the optimal soil management. In Holland soil management is a main topic for many years in the work of Louis Bolk Institute together with the pioneer organic fruit growers and their consultancies. I will tell you about some aspects I learned in these years.

At several organic orchards you will see several systems: black tree strips, undergrowth, sandwich-strip, weeds, mulching, green manure, drip irrigation, overhead sprinklers, cow manure, chicken manure pellets, and, at first sight, some contradictory systems. They all can be optimal for some situations. The art of soil management is to decide what the optimal strategy for each situation.

Organic fruit growers can use some help in recognising the characteristics of their soil, be aware of the direction they want to develop their orchard and know the technical possibilities to reach that. Such a helper is the modern consultant for organic agriculture. The fruit grower asks researchers to provide the research results in a form that the grower can recognise if this issue fits in his/her development direction or not.

Feeding the tree by the roundabout of feeding soil life

Fruit growers know especially for fruit you need a well-drained, moist and well-aerated soil. Continuous moderate growth is the basic for fruit production and quality.

Soil life (bacteria, fungi, worms, etc) provides such a good soil for fruit. They build a soil structure that drains if wet and sucks up water if dry. Soil life feeds on raw organic matter, root exudates, grass chippings, fallen leaves, prunings, animal manure and decaying weeds. The humification part of soil life produces soil structure and humus. The mineralisation part of the soil life converts humus into easy uptaken nutrients.

In conventional fruit growing fruit growers use artificial fertilisers, dry or in fertigation, with the benefit of easy application, well-timed and well-dosed. In organic fruit growing, where a good soil structure is a basic condition, we use the roundabout of feeding the tree by feeding soil life. For the extra labour of the application of compost or composted manure you will get in return the labour of soil organisms: a better soil structure, a more regular water household, a better balanced input of all kind of (trace-) minerals and less leaching of minerals into

ground water. The soil is not a dead substrate just to prevent trees being blown away, but a living organism connected and fed by root exudates of the fruit trees and undergrowth. This total system must be well cared and forms the basis for fruit production.

Nutrient balance

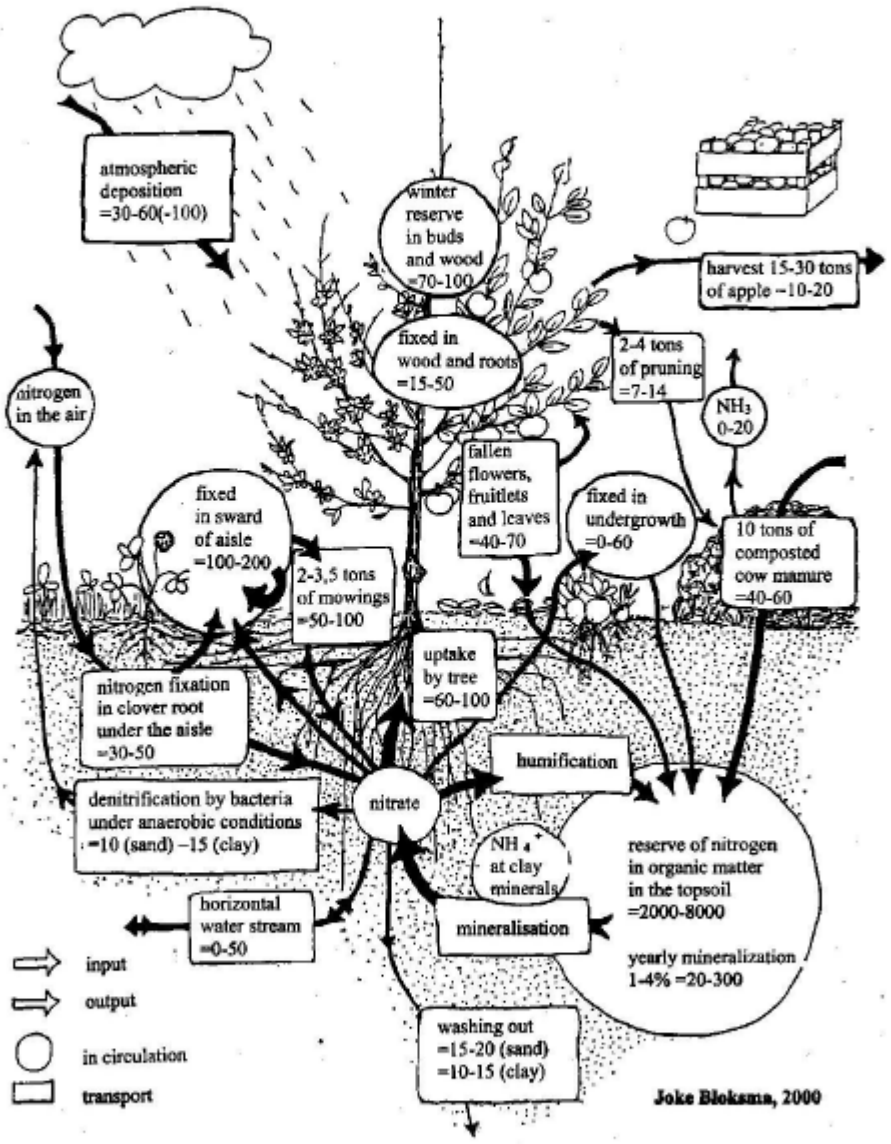
In modern agriculture forming a nutrient balance is a common instrument to judge the fertilisation management and prevents losses into the environment. Simple balances are based on an idea of the soil as a dead system with minerals coming in by fertilisation and carried off by sold crop and some unavoidable losses. Sold fruits and growing wood only consist of a few minerals. Replacing them only asks for a little fertilisation. Doing this in conversion or a young orchard will get you into a shortage. Nutrient balance thinkers forget they build not only a crop but also a living soil. In vegetable growing this mistake is not too large, but in fruit growing you may not do this. Building a sward of grass in the aisle and enlarging organic matter in the soil asks for much more fertilisation than growing a fruit shrub or tree.

Organic matter in the soil has the function of financial capital in business. Starting a new orchard on ploughed meadow sward provides much more starting capital than starting from arable land. A new orchard on arable land needs a larger starting capital injection. Improving the soil structure is the profit of the invested capital. As you will not see from the outside of an enterprise there is much more inside circulation of money as you thought. See the drawing of the nitrogen cycle of an apple orchard.

Mineralisation processes provide a steady flux of nitrate from the humus, also when fertilisation was long ago. For this process the bacteria need humus, a soil without poison, and moist and warm conditions. With a yearly mineralisation of 1-4% of the humus, as is usual in organic soil in the Dutch or English climate, you provide between 20 and 300 kg N per hectare. This ranks between too little and too much for an orchard. Management of the mineralisation process is much more important than the amount of fertiliser. And so we come to tillage, weed control and water management.

I give a more complex balance for an organic apple orchard. Not for using these figures as fixed, but to get an idea of the order of the meaning of the several processes.

Nitrogen cycle in the organic apple orchard in kg N/ha



Nutrient balance for an organic apple orchard (J Bloksma 1998)

amounts in kg/ha per year 2500 trees/ha, M9, 50% aisle with grass+clover	**nitrogen** **N**	**phosphate** **P_2O_5**	**potassium** **K_2O**
in wood, root of the young tree	15-50	6-14	20-40
in the young sward or the aisle	100-200	80-300	80-250
total fixed:	**115-250**	**86-314**	**100-290**
winter reserve in buds and wood	70-100	20-40	0-10
fallen flowers, fruitlets and leaves	40-70	10-20	38-65
prunings (2-4 ton)	7-14	5-10	8-15
chippings of grass-clover (2-3,5 ton)	48-100	17-33	75-135
tree strip green cover (no grass)	20-60	7-20	30-90
total in circulation:	**175-344**	**59-123**	**151-315**
in harvest apples (15-30 ton)	10-20	4-8	30-60
leaching and volatilizing	25-50	2-4	20-40
total output:	**35-70**	**6-12**	**50-100**
atmospheric deposition	30-60 (-100)	-	-
fixation by clover in the aisle	30-50	-	-
mineralisation and weathering	20-300(-500)	20-300	50-500?
by horizontal ground water stream	0-50	0-20	0-50
total input:	**80-460**	**20-320**	**50-550?**
10 ton composted cow manure	40-60	20-40	60-120
20 ton liquid cow manure	50-70	17-25	80-100
4 ton dry chicken manure with straw	40-55	50-70	30-40

Nitrogen dynamics

Nitrogen is a very important element in the physiology of a fruit tree. Fruit growers know: less in spring reduces fruit set, too much in June gives heavy dropping, too much in August reduces ripening and quality, too little in late summer makes weak flower buds for the next year.

Pioneers of organic fruit growing (Lust, Fürst, in the 1970s) learned in organic vegetable growing the importance of a high amount of organic manure, green manure and improving soil life. In fruit growing, however, this system leads to extreme mineralisation in late summer warmth and so leads to severe growth and less ripening. We learnt from these mistakes. Fruit production asks for a moderate soil activity, the accent is on building organic matter as in wood soil and not as much on mineralisation as in vegetable growing.

In organic orchards in our climate we often see a shortage of nitrogen at flowering time when the soil is too wet and too cold for mineralisation. When therefore fertilisation is improved you will find in many cases a surplus in late summer.

In conventional fruit growing literature you will find some thresholds for minimum nitrogen in the soil. Mainly known is the 50 kg N-min. in 0-60 cm depth in June (Quast 1996). In the organic orchards I also found less nitrogen and still production was fine over many years. When soil life conditions are good, the nitrogen flux can be quick (=it is produced quickly and is taken up by the roots quickly), without high values at one moment, but enough for the

tree. Especially at tree strip with green cover I found this mineral N measurements of no use. The leaf analyses give better information to know what is really taken up.

For a small root system (dwarf rootstock, root pruning, berms) the roots need a higher amount of N (more fertilisation and more environmental losses) than in a deep and large root system. If you can control growth, an orchard with large roots is more minerally efficient than trees with a few roots.

Leguminous crops reduce fertilisers

In this period with cheap artificial fertilisers and manure excesses in the rich world, we often forget fertilisers are the limited factor in agriculture. The movement of organic agriculture strives after independence of manure surplus from conventional agriculture. This means organic farmers must use manure as efficiently as possible, prevent losses and uses leguminous crops for nitrogen fixation as much as possible. A specialised fruit farm without cattle has limited possibilities for legumes, but there are some: grass mixed with clover in the tramline, clover in the tree strip, one or two years of leguminous green manure before planting the trees and for larger farms a rotation with leguminous fodder crops and fruit crops.

Multifunctional aisles

The concept of 'multifunctional' aisle means we use the aisles not solely as access routes but also to produce organic material, to fix extra nitrogen by clover and provide a site for flowering plants for bees and natural enemies.

Together with a seed firm, Barenbrug in Holland, we developed a tramline seed mixture with grass and 10% white pasture clover to reach an optimum in organic matter production and trafficability ('Prosoil'). For existing grass strips it is possible to 'clean up' the grass with a shredder in April or August and over sow with some white pasture clover. Depending on what low umbellifer species will grow in the region, the fruit grower mixes some flower seed for natural enemies (dill, wild carrot, etc).

For some years LBI has counted the contribution of grass-clover in the aisle to the organic matter and mineral balance of several orchards. The yield of aisle mowings varied greatly. In a young orchard we replace about two tons of dry organic matter from aisle to tree strip which replaces ca. 50 kg N and 60 kg K per ha orchard. This home-grown organic matter reduces the need for manure. If the trees need extra potassium it is a good strategy to replace the mowings from aisle to tree strip. If extra potassium poses a risk to apple quality then keep the mowings at the tramline. Pears and berry fruit seldom have too much potassium, so this is a particular good strategy for those fruit species.

The following conditions are favourable for productive aisles: a young orchard where much light reaches the ground; broad aisles; white clover sown into the grass; a good soil structure; not much traffic and the sward not mowed shorter than ca. 8 cm. On loam, management was still good until 50% was covered by clover. To always provide flowers anywhere for beneficials access it is good practice to mow the aisles alternately and do the next time the other aisles.

Strategies for tree strip management

A number of advantages and disadvantages of cover crops are discussed in my Dutch book about Soil Management (1996). Briefly stated, the advantages include more soil life, better soil structure, increased organic matter content, better oxygen supply for the tree roots, better ripening, no mechanical tillage through the soil and less *Phythophthora* rot in apples. Possible disadvantages include growth inhibition through moisture and nutrient competition and risk of mouse damage. In recent years a great deal of experience has been acquired with various types of cover crops under a wide variety of conditions. For practise we distinguish the following strategies:

1. **Most of the year keep clear by mechanical tillage and hand labour** and only from July (when fruits are hanging low) till harvest allow weed cover. This system fits where is planting is very intensive, at locations with dry soil or in a young orchard. When mice problems are not severe it is possible to keep a weed cover in winter and the soil will dry quicker in spring. It is profitable to keep the tree strip as narrow as possible because of competition.

2. The **clover islands** method is an improvement of the above and the most minimal system of cover cropping, where a permanent 'island' of white pasture clover (*Trifolium repens*) is sown around the trunk and the stake, and the rest of the tree strip is kept free of growth. This system is suitable for an orchard where no irrigation can be provided. Broader cover cropping would provide too much competition with the trees in this situation. The hoeing machine is adjusted to hoe around the islands. The clump of clover appears to greatly reduce spontaneous grass growth surrounding the trunk. We assume that the clover clumps compete with the trees much less than do grass clumps. Moreover, clover clumps are much easier to remove than grass clumps and save hand labour.

3. The **permanent cover crop**, where white pasture clover (*Trifolium repens*) is sown and during the course of several seasons becomes spontaneously mixed with grass and weeds; the cover crop is regularly mowed (not under 10 cm high!). This strategy is suitable for fertile parcels, for somewhat older trees and where irrigation can be used. However, an ideal mowing machine is not yet available commercially, and no solution has yet been found for the increased risk of mouse damage.

4. The **late summer cover crop**, where a rapidly-growing green manure crop is sown in August which is mechanically removed in winter to avoid mice shelter. This strategy is suitable for young orchards where sufficient light falls on the tree strip, where there are not yet any low-hanging shoots in August when the seed bed must be prepared, and where some growth inhibition in late summer is necessary to allow the trees to finish growing and ripen their fruit. A great advantage of this system is the easy mechanical weeding in spring. Our experiments showed that the preparation of the seedbed requires much attention. The end of August turned out to be too late for sowing; the beginning of August was good for cruciferous plants (turnip=*Brassica rapa*, fodder radish=*Raphanus sativus oleferus*) and *Phacelia*). A clean seed bed tillage and sufficient nitrogen and water must be available for the cover crop to develop properly.

5. The **'Sandwich system'** is where a narrow strip about 30 cm wide is sown between the trees and a soil strip is kept free of growth on both sides by a rotary hoe without feelers. The term 'sandwich' indicates how this system, when seen from above, resembles a

sandwich; the dark soil strips resemble slices of bread and the strip of cover crop resembles the filling. It was developed in Switzerland by FIBL. This system combines the advantages of a tree strip that is kept clear of growth with those of a cover crop. Our research focuses on acquiring experience with managing various types of 'filling'. In the Dutch climate we experienced with success white pasture clover (*Trifolium repens*) and spontaneous weed growth. Other species were not worth sowing because weeds took over very quickly. As with permanent clover, the sandwich crop is mowed using a mower with feelers if it becomes too tall or if too many weeds are growing through it.

6. **Mulching with straw or bark chippings**. This system fits for very shallow root systems (as berries). It asks for extra nitrogen at the start. It is expensive for material and labour. Until now we wait for the invention of mechanical tool to manage the edge between mulch and mowed grass and to cut weeds coming through the mulch as couch. The plastic or woven mulch cloth is less ideal because of waste of material, damaging by grass mower, mice, management of the edge between cloth and grass and creeping weed from the aisle.

Tools for tree strip tillage

Last decade we saw good progress in mechanical tools for tree strip tillage in a very shallow and quick way. Many good tools from wine growing were introduced into fruit growing. At the moment the grower has to choose between many type of tools, each with advantages and disadvantages. The tool of the future is one that combines tools for different situations: rotary harrow or disc-harrow (severe sward, moist, making seedbed), flat share (quick, dry soil) and mowing under the tree (green cover) with tasters.

Fertilisers

In my opinion the optimal feeding management is to feed the soil with raw organic matter as basic fertiliser and also have the opportunity to feed the tree for corrections with easy minerals in case of cold wet weather.

We have good experience with basic fertiliser as organic compost (compost from mushroom breeders) and self-composted organic cow manure. Of course, a main source of raw organic material to feed soil life is grass mowings, wood chippings, fallen leaves, flowers and fruitlets. Also, without organic manure the organic matter balance is positive for an orchard. Composted animal manure stimulates and leads to diversification of soil life much better than bloodmeal, dry chicken manure pellets or slurry.

Because of the consequent EU standards in organic agriculture there is not much choice for correction fertilisers or for organic fertigation. Urea is not allowed because of its synthetic source. High nitrogen sources, such as bloodmeal from intensive animal keeping or fluid aminoacid from animal destruction does not fit in to the ideal of sustainable organic fruit growing and will disappear in future.

After being involved with optimising nitrogen dynamics for many years, I will finish with the remark that some people focus too much on nitrogen. Production and flower buds are based on assimilates and not on nitrogen. Only in some cases you can say nitrogen is the limiting factor in assimilation. Much more often it is the quality of leaves (scab, mites), the uncontrolled vigour or lack of soil moisture.

Literature in English or German about soil management in organic fruit growing

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