

Some Hidden Benefits of a Healthy Organic Soil

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After 6 years agricultural training and 54 years involvement with vegetable products, I have become very aware that most farmers are not sufficiently educated about the role that the soil plays in producing healthy crops economically. There is insufficient emphasis by agricultural institutions in educating students on the care of the soil environment.

The problem that many farmers face is that the soil condition is not easily discerned unless one is educated on what to look for. Like with human health, it is accepted that about 80% of one's immune system emanates from the volume and composition of the gut bacteria. One cannot visually discern this condition by just looking at a person and soils are similar. A superficial glance at soil will also not tell one the true story.

Despite all my exposure to agricultural production, it was only 17 years ago that I came to realise both the value of a healthy soil and as to how to generate a healthy soil. Ironically, this was due to an accident. When I acquired a 3 acre land on which to do my vegetable plant breeding, I used the services of a local farmer to rip the virgin soil and incorporate the necessary minerals as indicated by a soil analysis. A bed former was then used. I used a hand rotavator to prepare for planting and incorporate fertilizer. Every 2 years the farmer would re-rip and form the beds again.

The soil is a red Hutton form and was heavily infected by root knot nematodes (*Meloidogyne* spp.) and without fumigation, susceptible crops could not be grown. In addition, the carrot breeding was made more difficult due to *Rhizoctonia* which meant that much more plants had to be produced in order to select unaffected stocklings for transplanting for seed.

After applying fertilizer and having nearly 100 bean varieties to plant, the rotavator would not start and I reluctantly had to make drills and plant without cultivation. It was a huge success and I experimented with other species and also had good results. After a couple of years, I noticed that the soil condition had started to improve rapidly. This was 17 years ago and I have not tilled the soil since.

Noticing the soil improvement and knowing that humus has a C:N ratio of about 10:1, I wondered if there is a formula so as to be able to quantify the amount of humus that can be formed from crop residue. After a number of consultations with agronomists in S. Africa, I could not get direction on this. I then contacted the professors of agronomy at 3 USA universities. Two were very vague but the third, Kansas State University professor of agronomy gave me the formula and added that all his students have to do a project to prove the formula.

It turns out that in most crops there is about 400 kg of carbon per tonne of dry crop residue. Of this, 140 kg has the potential to produce humus with the remainder released as CO₂ into the atmosphere as a by-product from soil organism activity as the raw material is rendered to humus. As the humus is about 50% C, there is potential to produce 280 kg of humus from 1 tonne of crop residue. With the C:N of 10:1 and 140 kg of C for humus formation, there has to be 14 kg of N per tonne of crop residue in order to maximise humus production. In the case of wheat residue which is about a C:N ratio of about 80:1, there would be a shortfall of 9 kg of N per tonne of residue which means that only 100 kg of humus could be formed in place of a potential 280 kg if sufficient N was available.

Last year, I weighed a section of dry vetch mulch which amounted to 18 tonne/ha which included the roots. This would produce 2000 kg of humus containing 200 kg of N.

The formula enabled an understanding as to why some agronomic farmers would get a steady increase in humus content whereas others would get no benefit. It turns out that those producing a legume like soya beans in a rotation would benefit from the system. In my experience, there were very few exceptions and the debate on the benefit of no-till will rage on until the knowledge and understanding of the formula is understood by all farmers.

Since I was informed of the formula, I have started planting grazing vetch at my facility as this legume fits in well with my off season for plant breeding. It has made an enormous difference to my soil condition. Two rows are planted per bed which are spaced 1.8 M apart. Just before seed set, the vetch is raked to the middle of the beds and then cut at ground level with a spade leaving a 50 cm wide mulch on the bed and planting of crops on the edge of this. This mulch lasts for many months providing soil protection and feed for earthworms and wood lice with the benefit filtering into the soil profile through fungi, actinomycetes, bacteria, etc.

The *Rhizoctonia* on carrots has disappeared, eelworm is no longer a threat, rust on my beans has virtually disappeared with treatment required and white grubs (beetle larvae) which used to eat the roots of my brassicas, do not do so anymore. In periods of prolonged rainy periods, virtually all outdoor farmers in my region suffer from much damage from *Phytophthora capsici* whereas I have never had a single plant succumb since breeding capsicums.

A further benefit is that now for many years I have not had to apply any artificial fertilizer whatsoever. The small area not used for winter vetch is fertilized with some compost left on the soil surface which is superficially incorporated with hoeing for weeds. Whereas most farmers use about 180 kg of N per ha on cabbages, I can get heads weighing 5 - 9 kg with none.

Quite apart from the usual benefits of humus which are very well known, the amount of living biomass now in my soil which amounts to several tonnes, is a living reservoir for soil minerals. During rainy periods, all our conventional vegetable farmers have to apply considerable quantities of nitrogen to replace what the rain has leached. I can have hundreds of mm of rain in a week or 10 days and still not have to apply any N.

In a conventional cropping system in S. Africa, the humus content is relatively low. The nitrogen applied is either in the ammonia form or ammonium nitrate. The nitrate being an anion is free to leach through excess water by rain or irrigation whereas the ammonia is adsorbed to the soil colloids where it is safe until converted to nitrate by bacteria. In my case, the nitrogen is tied up in living organisms and free from leaching. As bacteria have a C:N ratio of 5:1 and protozoa with a C:N ratio of 10:1 which are a major consumer of bacteria there is a lot of excess nitrogen excreted by the protozoa which is used by plants and other organisms with recycling constantly taking place and only a very small proportion becoming vulnerable to leaching from heavy rain at any time.

The negatively charged clay colloids in soil have a cation exchange capacity only. Humus on the other hand, apart from having a considerably higher cation exchange capacity than clay, also has an anion exchange capacity capable of holding some nitrate. It seems that the extent of this has not been quantified.

From what I am able to discern, humus is appreciated by many as beneficial for soil with less importance appreciated for the living organisms that are sustained by it. One has to have a constant amount of raw biomass to keep the cycle continuing to maintain this with the amount of raw material, temperature and soil type influencing the level at which it becomes static. My system is static at about 5% humus.

There is an interesting case in South Africa where an agronomist who was a pasture consultant, noticed a patch of crown vetch which had invaded a section of a main highway near the town of Mooi River. He took a soil sample of the vetch area and another of the weedy

area alongside. The difference was truly amazing. So many minerals became available from the vetch and the phosphorous content was considerably higher where the vetch had been growing for a number of years.

Apart from the benefits of cost saving and less capital tied up in equipment when practicing no-till, the build-up of humus will remove a huge quantity of carbon from the air. No-till is perhaps not practical for all crops but it is important for farmers to realise that tillage generally does damage to the soil structure and organic content and should be limited to just get a crop planted.



Figure 1: Vegetables grown on ground last tilled 15 years ago and no fertilizer.



Figure 2: The soil on the LH side is the improved soil with 5% humus and the RH soil is from the edge of the land representing the soil as it originally was.



Figure 3: This grazing vetch mulch will feed soil organisms and increase humus.

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