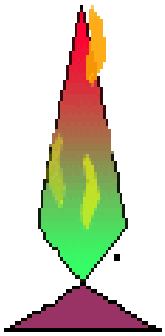

Ex.3:2

RENERTECH.

Renewable Energy Sources.

Technology For Rural Development.

Electronic Aids to Agricultural Efficiency

Phone. +64 3230 4525
Fax. +64 3230 4525
Email renertech@xtra.co.nz
Web. www.coffee.20m.com
VoIP. Renertech1@Skype.com

Ken Calvert.
183 Drysdale Rd.
R.D.2 Invercargill.
New Zealand. 9872.

Dated. 11-7-2016.
Your Ref:
Mine.

How to grow **'SUSTAINABLE' 'ORGANIC'** Coffee.
By Conservation Agriculture.
The Microbiology and the Method.

For Bird Friendly & Kids Friendly Coffee.

From my point of view:

As you peruse the rest of my website I am sure you will realize that my major interest is with the 3rd world coffee growers and pushing back the poverty barriers. However, I am believing that what the 1st and 2nd World wants, in this instance, the small holder coffee industry of the 3rd world cannot produce enough of. Despite all the negatives, I am ready therefore to extend my experience of large scale plantation industry to keep discerning coffee drinkers in the front line of developing technology and superior 'gustation,' as well as good conscience. It is my personal opinion that the environment suffers more from the processing of coffee than the growing of it, but for that you need all the rest of my website. From this point on we stick to the growing process. And do read my last paragraph.

What the world wants:

The so called developed and more sophisticated world wants to have a clear conscience when drinking their favourite beverage. They want to think that they are not exploiting poor people nor damaging them with those chemicals that they use to produce coffee, and they are not damaging the environment. Most poor people who grow coffee do not use pesticides and herbicides, nor do they use imported synthetic chemical fertilizers. Because they can't buy fertilizer they have to grow shaded coffee by clearing out the undergrowth under existing forest and unfortunately not trying too hard

to keep the birds and bees. They grow 'organic' coffee. But the discerning world will not buy it because the beans are small and low in carbohydrates and proteins, the stuff that roasts into lots of solubles to give good 'body' and 'flavor'. Yes it is organic coffee in every true sense of the word, but the commercial world downgrades it to 'rustic' or 'naturally grown' coffee. And if the word organic appears it is always written in lower case. There is now however a swing over to conservation and sustainability[1] as well as organic terminology as being of much wider appeal than the older organic labeling alone.

What is ORGANIC organic ?

To meet the increasing demand for a high quality 'sustainable' coffee, organically grown but also with big AA sized beans and lots of solubles, it will be necessary for a lot of existing open 'sun coffee' plantations to swing back over to the organic scheme of culture[2]. The economics of such a change are decidedly negative. Many of those non coffee growing authorities who have proposed such a change,[3] have since removed their websites. Nevertheless, for those who seriously want to have a go, this is the best way that I know. You can continue to market your coffee as of now until the accrediting authorities, who charge the earth, will run down the clock on your old patterns. That could take 5- 6, more likely 10 years if you start from scratch, to satisfy the more strict authorities on present statistics. Furthermore the swing over to even partially shaded conditions, as advocated, and making additional space to grow nitrogen means that per unit of land area under plantation conditions, one can only grow less than half the coffee, but nobody wants to pay double the price! This paper should really be part 5 of my series under the Microbiology heading, and I have already given some pointers under my previous efforts for the Honduras, how to grow Organic coffee, and the Trifinio Label, but in order to get Uncle Google to pick up the changes and push me up the search engine ladder I am creating this, with all the right key search words up front, and under a separate heading.

What we are allowed:

The organic rule book is fairly precise[4], but there are plenty of ifs and buts that can extend ones choices. Lets start off with just the basic fertilizer accoutrements that one can use under an organic regime. Raw rock potash, raw rock phosphate, limestone, gypsum, dolomite and biochar. Guano if you can get it. I would be advocating the use of gypsum instead of limestone, as sulphur is also a necessary part of good fertility. And, as coffee prefers a slightly acid soil, gypsum has a lower pH level than ground limestone. All these ingredients will probably have to be imported, but in this paper we are looking specifically at a larger scale commercial operation, under a time constraint, which is aiming for sustainability as well as an organic signature. As for trace element minerals there are lots of choices[5] just as long as only small amounts are required.

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[1] http://www.conservation.org/stories/Pages/Sustainable-Coffee-Challenge.aspx
[2] http://www.coffeehabitat.com/
[3] *http://www.fws.gov/caribbean-ecoteam/shade_coffee_FS.pdf*
[4] http://www.ecfr.gov/cgi-bin/text-idx?rgn=div6&node=7:3.1.1.9.32.7#se7.3.205_1622
[5] http://soilminerals.com/Minerals_and_Fertilizers.htm

'Conservation Agriculture' as it is now known has three basic principles, itemized in the FAO website referenced above:

a/. To minimize on soil tillage;

b/. Maintain ground cover by planting mulch and cover crops;

c/. To rotate crops of different plant genera. It's the last criteria that is the tough call for tree crops such as coffee. However we can minimize on the image of coffee as a monoculture by using other species as shade, and shelter. If the major organic authorities[6] will not accept this method of coffee production by 'manufactured' shelter systems then keep looking. Most third World coffee countries have their own licensing system which is much less stringent than the International biggies in the game. And if you can sell to a large franchise, they will soon give it their own superior labeling. As I understand it, the only analyses that third party certifying agencies can perform to check on samples is a gas chromatographic check on unusual organic residues usually from pesticides etc. And for chemical fertilizers the test is for 'vanadium' which corrodes off the steel equipment used to process the fertilizers. Having some background in GC tests for natural chlorinated compounds (rio flavor), these kinds of results are very subjective. The best defence is to retain all your dockets and invoices for every purchase made for whatever trivial purchase and make sure they correlate with your bank statements. That is their main line of investigation, and it does not allow for cheating by cash purchases.

Recycling what we can:

Of the coffee cherries that are picked and processed, 80% of their nutrient and mineral content is exported as the green bean fraction. Only 20% can be recovered from the pulp and skins as compost. It is also possible to make biogas from coffee wastes. See my microbiology series[7]. But the mucilage the major component of waste water is pectin or 'soluble dietary fibre' and will not ferment. Furthermore, the hulls of fine washed coffee parchment have virtually no nutrient value and are very difficult to turn into compost. Therefore some extra processing is necessary to convert these recalcitrant materials into energy rather than agricultural materials.[8]

Nevertheless, the biggest percentage of that 80% exported content is the photosynthetic fraction, produced by sunlight, and that is totally sustainable. In a 'live healthy' soil much less imported allowed fertilizers, only around 25-30% of previous levels, may be needed because the microbiology holds onto all the fertilizer ions positive and negative, . allowing very few to be leached into runoff or ground water. Furthermore, passage of finely ground rock phosphate (we call that reactive rock phosphate in N.Z.) through an earthworms gut, to perform the grinding action of their gizzards, will activate it very nicely. However, beware of North African mined rock phosphate, it has too much cadmium and other nono trace metals. So, be prepared to argue the point.

[6] https://en.wikipedia.org/wiki/Organic_certification

[7] http://www.coffee.20m.com/Publications.htm

[8] QV..4th section "The Microbiology of Coffee Processing." On this website.

Organics is really Microbiology:

The 'epiphany' here is that .'cation exchange capacity', what the organic fertilizer people pontificate about, will only hold back the cations, ie. ammonium, potassium , calcium magnesium and little else. In contrast, bacteria, given supplies of fertilizer ions, plus biological root extrudates for energy, and working in warm temperatures can double their numbers every 15 to 20 minutes. And every new bacteria or fungal hyphae will just as quickly take up all those materials and very quickly turn them into complex organic body mass which is not leached out, vapourised or lost, whatever the weather patterns. It is only when bigger soil protozoa, arthropods, insects and earthworms digest those microbes along with soil particles and excrete those previously inert fertiliser nutrients allowed by an organic regime, back up on the surface, as highly active 'castings' in the case of the earthworms, that a living active soil shows it true value. It is totally sustainable and recyclable and nothing is wasted. Indeed it's the fungi that activate those inert minerals that compose the basic mineral structure (dirt) and keep up renewing the supply of fertile 'soil'[9].

Of particular mention is the need for soil organic matter to stimulate the microbiology at the bottom end of the food chain[10]. The quickest way for a leached out plantation soil to be revived is to locate a source of organic carbon, ie. peat, lignite or low grade brown coal. These materials are historical sources of humus which have been preserved by anaerobic processes for eons of time to make very concentrated sources of organic matter. However, expose any of them to atmospheric conditions, grind them finely enough, and they will rapidly activate and stimulate the growth of soil fungi and bacteria. They are much superior to biochar, when it also comes to latching onto minerals, and are even more natural and organic than biochar. Unfortunately they always seem to be in short supply in the tropics, through The Central American States and India do have fair supplies.[11]

The traditional way to boost soil organic matter is through compost. However there are many ways to make it. Hot, Cold,[12] [13] Vermicomposting,[14]w hich takes time to build up the worm population. And the traditional Home gardening 'Add as you go' method.[15] For a coffee plantation siderowing mulch under the trees, it's the bacterial 'cold composting' and 'vermi- composting' methods blended together. And, as mentioned further below, every odd looking slater, millipede, beetle and earthworm that you find gets added into the mix. If they are benefical they will thrive, and if not they will either get eaten out or die out. If you have imported something special, then make a special compost pile with the right conditions to multiply them before spreading them around.

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[9] http://grownourishlove.com/permaculture/turning-dirt-into-soil/
[10] https://en.wikipedia.org/wiki/Food_chain
[11] http://specialpapers.gsapubs.org/content/179/65.abstract
[12] http://www.almanac.com/content/how-compost-hot-and-cold-methods
[13] http://www.finegardening.com/hot-composting-vs-cold-composting
[14] http://lancaster.unl.edu/pest/resources/vermicompost107.shtml
[15] http://www.homecompostingmadeeasy.com/addasyougopile.htm

Chasing Nitrogen:

The big hole in this fertilizer lineup is nitrogen. There are no sources of organic nitrogen concentrated enough to be shipped or transported long distances. Its largely a case of making your own. Despite being around 80% of our atmosphere. It takes a lot of energy to transform atmospheric nitrogen into fertilizer, 16 biological ATP energy bonds[16] to turn one N_2 gas molecule into 2 NH_4^+ ions, and that is where so much of the input provided by microbiology comes in[17]. The Rhizobia, Mychorrhiza, Trichoderma, and Verticillium families, which are sold by manufacturers, plus all the other soil biota[18] we know not of, are all microbes and fungi that grow in association with certain species of plants, and particularly with their root systems. The Rhizobes fix the nitrogen; The Mycorrhizae extract and supply the soil fertilizer nutrients; The Trichoderms and Verticilliums supply plant protection mechanisms. They all play a part in return for feeding on the carbon based energy compounds that are extruded by those plant roots. The area of soil close to plant roots and growing these microbes is called the Rhizosphere. To develop a rich rhizosphere that holds onto fertilizer nutrients and yet actively circulates soluble fertilizer ions , both positive cations, negative anions and organic complexes, we need to have earthworms. Or more precisely the whole soil microbiology that peaks with worms. Earthworms are only one of the top predators of a whole soil food chain or soil food web[19] of soil insects and protozoa and the food they live on, soil bacteria and fungi.

Building the Microbiology:

If we start by enhancing the levels of soil bacteria and fungi everything else including earthworms should follow on automatically. There are very few soils that don't have a few earthworms, but they do breed fairly quickly when conditions become conducive, and they can be added from other sources if required. In my advice to the Trifinio people I said; "When you see somebody with better coffee than you, snitch a handful of their soil that's close to the trees and put it around a couple of your trees. When you see that they are doing well, use that soil with your new seedlings and spread it around. That's the cheap way to get good microorganisms". But if you are trying to convert a whole plantation over in a hurry, go out and buy them.[20] [21] [22] [23] [24] The most universally popular set of bugs is that from Prof. Teruo Higa from Japan, which he has called 'Effective Microorganisms'.

These collections of selected organisms operate on two premises.

A/. Selected microorganisms can improve soil fertility and availability of basic minerals.

B/. Flooding the area with beneficial microorganisms can suppress many of the bad ones, ie. disease producing species. Just remember where all our medical antibiotics came

[16] https://en.wikipedia.org/wiki/Adenosine_triphosphate
[17] http://www.scribd.com/doc/27429437/Soil-Microbiology#scribd
[18] https://books.google.co.nz/books?id=0eg5jf8MllEC&dq=paenibacillus+and+nitrogen+fixation&lr=
[19] https://microbewiki.kenyon.edu/index.php/Soil_Food_Webs
[20] http://extension.oregonstate.edu/douglas/mg/dcmg/aerated-compost-tea
[21] http://www.nutri-tech.com.au/products/microbial-products/4-20
[22] *www.eric.com.au*
[23] http://www.soilandplantlaboratory.com/pdf/articles/BeneficialSoilMicrobes.pdf
[24] http://enviroinnovators.com/html/soil_microbes.html

from.[25] These organisms should ultimately eliminate the need for complex chemical biocides. Various EM collections can now be bought locally in just about every country in the world[26]. Moreover, as living things they can be bred up and multiplied ad infinitum by using them to make 'compost tea,' both aerated and steeped.[27] [28]. It is easy to spray on these liquids, both foliar on the leaves, and down on the soil. However, Just about anything organic can be added in small amounts to the brew to multiply any other specific organisms by this method.[29]

More on those Earthworms:

Worms that burrow smooth and strengthen the walls of their burrows with coatings which are basically capsular slime[30] from their favourite edible microorganisms. It is those same coatings that break down the plant matter they drag into their burrows, and filter the minerals from the soil water that drains down the open burrows. They also grow the worms next slurpy meal, and activate the soil particles they attach to tomorrows worm castings that keeps everything in constant circulation. [31]

It is this overall process of soil development that makes all the difference to transforming the typical bare tropical plantation soils into a sustainable base for growing genuine organic coffee.

. To make sure of getting other larger bacterial predators .such as protozoa, miniscule arthropods, nematodes etc. from other parallel food chains it's a case of going looking in covered damp places to pick up local microflora to insert into the system via the making of compost as mentioned above. However, be aware that the climate has a great effect on the microbiology as well as the plants, so don't use temperate climate inoculums on tropical plants and vise versa.[32]

The days of casual importation of earthworms from abroad is well and truly over. However there are sure to be several species already in your area, if not somewhere else in your country. There are three basic types Epigeic, Endogeic and Anecic worms[33]. Of the Epigeic or compost worms, they live in the top soil but don't really burrow down in it. The most common one is Eisenia foetida.. These are the ones that proliferate in food scraps and compost bins. It is generally recognized that this voracious species cannot survive in a field situation where the pickings are thin. However they can survive in the line of fermenting biomass that you side row under your coffee trees. They love the slimy vege breakdown products and the bacteria and fungi that produce them, and they will quickly process or compost a good thick mulch that is kept sheltered and as damp as possible under the shadow of the coffee trees. Worm are like chickens, they have

[25] https://en.wikipedia.org/wiki/Antibiotics
[26] http://emrojapan.com/media/uploaded/partners_asia.pdf
[27] http://www.motherearthnews.com/organic-gardening/gardening-techniques/aerated-compost-tea-zebz1307zsie.aspx
[28] http://extension.oregonstate.edu/douglas/mg/dcmg/aerated-compost-tea
[29] www.finegardening.com/brewing-compost-tea
[30] https://en.wikipedia.org/wiki/Slime_layer
[31] http://sciencelearn.org.nz/Science-Stories/Earthworms/Earthworms-role-in-the-ecosystem
[32] http://www.rainforestconservation.org/rainforest-primer/rainforest-primer-table-of-contents/g-rainforest-ecology/10-roles-of-fungi-and-other-microbes/
[33] https://en.wikipedia.org/wiki/Earthworm

gizzards to grind up their food, but no teeth. The descriptive word is 'slurp' rather than 'bite'.

The Endogeic or 'earthworker' worms are the most prevalent worms in field conditions, particularly in the tropics. They ingest both soil and organic matter and excrete worm castings both above and within the topsoil layer. These are the worms that recycle fertilizer ions and actively till the topsoil. A brick or a plank left on the surface will get buried by these worms extracting underneath and excreting on top. There are lots of different families and species but the names are unimportant, just as long as you have some. Google on Worm "grunting, charming or fiddling"[34] if you need to go out and find some.

The Anecic species are the deep working ones that create deep vertical burrows. They are not nearly so prevalent in shallow topsoils with strong clay or coarse sandy subsoils. They are the ultimate tilling species but are hard to collect if they are not already present.

Secondly the Shade:

Because developing the soil, even with all this microbial assistance, still cannot produce enough nutrients for the roots to supply dark 'sunleaved' coffee growing even in partial open sunlight, (See more below) we do have to regrow shade in our plantations to keep roots and stems in balance. I can suggest ways to do that if you have no good varieties of trees in your area. However, local varieties are always the best, judged over generations of ancestors to do the job. Not only in a minimal time frame but also with specific trees that fix nitrogen as well as shade.

There are four requirements for shade in a coffee plantation.

1/. Shade from direct sunlight for a certain number of hours per day;

2/. Shelter from prevailing winds;,

3/ .Shelter from rain impacting directly on the soil and causing excessive runoff from surface compaction. And lastly;

4/. Sheltered racks to hold the growth of epiphytes, and their resident insects, for migrating birds[35] [36] [37] Epiphytes do nothing for the coffee. But the Smithsonian Institute, the Rainforest Alliance, Kids Friendly and so many other environmental agencies have used coffee to market their own requirements. And it is their advertising and endorsements that the coffee industry needs to reap the market enhancements needed for the extra effort to grow a higher value product. Encourage the owners to start with orchids and bromeliad epiphytes for beauty as well as utility Those they may see the sense of, and the better insect reservoirs for the birds can follow. Those licensing authorities mentioned above may not condone a manufactured shade forest setting like this, but you can still legitimately print 'bird friendly' on your own label. And be aware that Central America is not the only place that birds migrate through.[38]

[34] http://modernfarmer.com/2014/08/worm-grunting/
[35] https://nationalzoo.si.edu/scbi/migratorybirds/science_article/?id=138
[36] http://www.stri.si.edu/english/research/facilities/terrestrial/cranes/biodiversity.php
[37] https://nationalzoo.si.edu/scbi/migratorybirds/science_article/?id=198
[38] https://ecofriendlycoffee.org/ecofriendly-cofriendly-shade-coffee-as-stopover-sites-in-bird-migrations/

Shelter can usually be achieved with two types of trees. First, lines of tall growing trees with filmy fronds such as a Casuarina species,[39] in rows wide enough, to allow about two hours of direct sunlight end on to the rows of shade. Depending on ones latitude it's a case of marking the travel of the sun for two hours, then allowing about 5 metres for the top spread of the trees themselves above the pruning level. Those lines should also be aligned to break up the prevailing winds and create weak eddy currents down where the coffee is. A prevailing wind will still dry out a good soil even with a good layer of mulch or herbal coverage. Try and avoid the mid day sun down the rows for those two hours if possible. Casuarina is good for tall sun shading and wind shelter. It feeds seed eating birds[40], and it fixes nitrogen,, not with rhizobia but with a actinomycete fungus species called 'Frankia'.[41] Its rough bark, if it is encouraged by perching as many local epiphytes as possible at the junctures of its branches to get it started,[42] [43],and also with close pruning, Casuarina will cater for many of the migrating birds passing through. Uncle Google will fill you in on all the details[44]. Keep clipping the branches, right from the start in the same way as you trim a fence line always leaving a growing tip.[45] Then you will end up with either a rough hedge shape, or furry bean poles with wide spreading tops that just meet, if they are spaced just right. If you leave the trimming for too long, the branches will not regenerate growth and you will be left with bare poles.

Getting tall shade started:

As mentioned elsewhere growing shade trees that need to be constantly pruned at regular intervals is a slow business. And if you are trying to do it in an existing open sun coffee plantation, it is a nighmare! . In a well established sun coffee plantation with say dwarf Caturra, close planted coffee, 5000+ stems/Ha and rows 1.5 metres apart and well fertilised, the yields will always be considerably more, at least double anything even remotely organic setups can achieve. Such close planted set ups will have to have every second row removed, hopefully replanted elsewhere, just to get space to grow the Arachis ground cover for mulch. Even at a lesser spacing 2.5 x 2.5 metres and 2,500 stems/Ha, it will also require at least 3 rows removed along the line of tall primary shade trees. I sometimes think that the 'O' coffee fraternity have no idea of the trauma they can inflict on the established plantation industry.

To get things started try planting a line of bananas spaced around 2-3 metres apart in the rows and plant the tall shade trees in between the bananas. Give them plenty of fertilizer, because you still have a long way to go to achieve organic status, so give the shade trees every encouragement while you can. Once you have got them about 6

[39] https://en.wikipedia.org/wiki/Casuarina_equisetifoli
[40] http://www.burkesbackyard.com.au/fact-sheets/in-the-garden/trees-and-palms/casuarinas/#.V4B_dM5OI3E
[41] http://link.springer.com/chapter/10.1007%2F978-3-540-78826-3_36#page-1
[42] http://www.isca.in/IJBS/Archive/v2/i5/5.ISCA-IRJBS-2013-028.pdf
[43] https://florafaunaweb.nparks.gov.sg/Special-Pages/plant-detail.aspx?id=2793
[44] http://www.gardeningknowhow.com/houseplants/epiphytes/adaptations-of-epiphytes.htm
[45] http://www.alibaba.com/product-detail/BEST-PRICE-GARDEN-TOOLS-MODEL-LHT330_60402595489.html?spm=a2700.7724857.29.91.Uqe4PD

metres, or as high as you can trim them using a power trimmer or hedge cutting machine,[46] let them spread out at the top when you will get soft filmy foliage that is ideal shade, and the trimmings will suppress germination of weeds and extra coffee seedlings in the wrong places. The trimmings make very good high protein mulch. The major problem with Casuarina is its wide spreading shallow roots, prone to blow over in hurricanes and one also needs a large straight disk plough or root trimmer to slice through its roots if they get too close to the coffee. If they do blow over you have an excellent source of building timber and fire wood. Once again replant the new row in between some extra tall bananas until they get away. As for those extra rows of coffee that need to be removed, wait until the recycle and then you can run the tractor with the disk plow over the top and close wrench the coffee roots. Let them recover for three weeks and then you can cut off the tap root with a sharp drainage spade angled in and hopefully lift out the stump with enough soil adhering to the roots to replant elsewhere. I would like to design a root stumping plough which would do the job without too much Physical effort but I don't think I would have too many takers. Why go to the bother or replanting? You will gain two to three years of crop over starting out fresh with seedlings. Most modern varieties of Arabica coffee are bred for disease resistance rather than improvement in beverage quality[47].

Sun leaves versus Shade leaves:

Without all the scientific explanations [48] [49] [50] [51] a comparison between the two, show leaves grown in bright sunlight are thicker and darker than those grown under shade. It may be as one biased reference says, that leaves in bright sunlight actually have a lower rate of photosynthesis than those in shade, but the source for that is doubtful. Sun leaves still feed a lot more roots because they are more robust and even with reduced chemical fertilizer can take up more sunshine and have increased overall photosynthesis. It is my considered opinion, based on personal experience, that planting a plantation with shade trees in such a way that the coffee trees are largely shaded, but still receive full sunlight for up to two hours each day, that the coffee, in a good healthy soil, will maintain sun leaves and will therefore grow bigger and fatter beans, AA gradings, which will produce a superior grade of coffee. Prove me wrong with facts and figures somebody please?

2nd stage Shelter:

In addition it's a case of removing another row of coffee for each line of 2ndry shade, just as with the Casuarina, but planting low growing but wide spreading fruit and nut trees.[52] Inga, Pacific almond, Inocarpus, Erythrina edulus, the more varieties the better. The only criteria is that they should preferably drop their leaves about mid season so that the coffee can get max sun for around two hours for cherry fattening and ripening. If

[46] https://www.youtube.com/watch?v=KBLmfhM5qGQ
[47] https://en.wikipedia.org/wiki/List_of_coffee_varieties
[48] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3990704/
[49] http://www.scielo.br/scielo.php?pid=S2197-00252013000100008&script=sci_arttext
[50] http://www.plantphysiol.org/content/72/3/674.full.pdf
[51] https://books.google.co.nz/books?id=pvANAQAAIAAJ
[52] https://nationalzoo.si.edu/scbi/migratorybirds/science_article/?id=198

you are starting from scratch, or want extra cash flow all year round, go for tall bananas with the shade trees planted in between. We are always led to believe that bananas are clean and free of pests and diseases. But that is because the industry is paranoid about the vulnerability[53] of their 100% dependence on the Cavandish variety. If you can plant as many different varieties as are to hand, and don't dose them in chemicals, you may not make much profit on the bananas but you will have more wasps, and the bugs and critters that they live on, plus the birds that eat the wasps and the bugs as well.[54] The wasp nests can be spot sprayed or dusted one night, just in time to let the pickers in for the coffee picking season. Otherwise left. Nevertheless, having to suit up your off season staff for wasps during routine plantation management may be a pain!

It is much more profitable to keep bees,[55] gather honey and improve the coffee pollination. Particularly if you have the sort of climate that can produce a flowering after every good rain.. (QV additional article on bees on this website.) However, now that the bees are africanized in the Americas, and decidedly more vicious, plus the potential problem with bananas exciting bees,[56] it's a mute point between the bees and the wasps. Birds will certainly eat both. At least you can house the bee hives outside the plantation and work them at night to avoid mass attacks . As already mentioned, the whole publicity about bird friendly coffee is generated by the 'Smithsonian Migratory Bird Centre', because of species, like the 'summer tanager', that pass down through the Central American states and need to have a spell and a good feed on the way. The Smithsonian concerns are understandable but do place empositions on coffee. Nevertheless we do need to comply, for marketing purposes!

Yes it's a problem to get enough initial planting stock for bananas, so start stock piling early on. There is also a whole industry in 'tissue culture'.[57] [58] Plant them in rows every couple of rows of coffee, and about 6-10 ft apart down the rows, depending on the species. Take out all the suckers for propagation except the one that will continue the row in a straight line. In this way you will grow a permanent line of shade with the actual stems walking down the line in continuous propagation. Believe it or not they also will grow nitrogen fixing bacteria.[59] Chop up each stem when it is finished and spread them around. The thing about bananas is that they can give cashflow in the interim period while the plantation is redeveloping. Bananas ferment very easily and make lots of local happiness,[60] although the smiggen of acetate or banana flavor is not well liked in international wine circles. Dried bananas and plantain for local eating and cooking is also a source of cash flow.[61]

[53] https://en.wikipedia.org/wiki/Cavendish_banana
[54] http://animals.mom.me/kind-birds-eat-bees-3848.html
[55] http://www.illy.com/wps/wcm/connect/en/press/press-realeases/illy-study-coffee-honey
[56] http://io9.gizmodo.com/how-to-murder-someone-with-bananas-and-also-bees-460444715
[57] https://www.youtube.com/watch?v=0svFGiDJPhg
[58] http://www.slideshare.net/sathes32/tissue-culture-techniques-of-banana
[59] http://link.springer.com/article/10.1023%2FA%3A1026283311770#/page-1
[60] https://en.wikipedia.org/wiki/Banana_wine
[61] https://nuts.com/driedfruit/banana-chips/wholebananas.html

Back to Nitrogen:

The major source of nitrogen has to be a leguminous ground cover crop such as Arachis pintoi, the perennial peanut. They don't make peanuts to eat, but propagate by seed. Do not go for climbing entwining viney species of legumes like Dolichos, Centrosema, Mucuna or Lablab. It is a continuous operation to keep such vines from growing up into the coffee trees A fortnights inattention and they are up into the places where you will pull off a lot of leaves to get them out and 6 weeks and you have a mat growing over the top. By 6 months you have dead coffee. A.pintoi is low growing, 60cms at most, but still dangerous. Let it get away on you and it will pull more nutrients out of the ground than coffee ever could and the coffee will be starved rather than shaded to death. The secret to growing high grade organic sustainable coffee is to use aggressive species of plants and trees to pull nutrients out of degraded soils and fix as much nitrogen as possible and then act even more aggressively to prune, trim and control these plants and side row the trimmings under the coffee trees to mulch its roots, keep them damp and cool and able to pump nutrients into the trees above. See elsewhere my comments about the Amazon rain forest. The fungus Verticillium lecani [62] now known as the White halo fungus, *Lecanicillium lecanii* [63] if one can encourage it to grow in your particular climate is a truly versatile pieces of microbiology in that it will attack both plant and insect diseases. It is commercially available on the Internet.[64] [65] And there has now been several varieties developed for different species of plants.

Killing the Cooties:

The major weakness of organic growing is the pests and disease problem. Copper being a natural element is allowed as an Organic material, as is old fashioned lime sulphur, and their related sprayable compounds like the old fashioned Bordeau mixture[66]. They certainly help, but are not a complete cure. It is a case of constant searching on the internet for all the latest developments. There is also a reference to the ability of direct sunshine to minimise the sporulation of coffee leaf rust.[67] Also verticillium sprays[68] [69]

Terracing your land:

If the plantation is on undulating or sloping land, then the use of Vetiver grass [70] to create terraces will significantly aid eventual mechanization as well as conserving vital soil water and erosion. Although it does not fix nitrogen of itself, Vetiver does harbour lots of bacteria that do, and mycorrhizal fungi that are able to extract phosphorus locked up in the soil.[71] [72] [73] The major factor about using vetiver

[62] http://www.jebas.org/00300420082015/10.18006_2015.3(4).337.345.pdf
[63] http://kumu.brocku.ca/BIOL_2P96_Jan_2013-group07/Lecanicillium_lecanii
[64] http://www.drrajanlaboratories.com/product7.html
[65] http://fertilisersindia.com/products.html
[66] http://ipm.ucanr.edu/PMG/PESTNOTES/pn7481.html
[67] Muller RA, Berry D, Avelino J & Bieysse D. 2009. Coffee Diseases. In: Wintgens, N., editor). Coffee: Growing, Processing, Sustainable Production. Wiley-VCH Verlag GmbH & Co. KGaA. p. 491-545.
[68] http://www.tstanes.com/mobile/biocatch.html
[69] http://www.arccjournals.com/uploads/articles/ar314001.pdf
[70] http://www.slideshare.net/mik1999/vetiver-for-terracing-and-stabilizing-soil
[71] http://www.vetiver.org/TVN_IVC2/CP5-4-1.PDF

however is water conservation. You can't grow big fat coffee cherries in dry ground. There is nothing like vetiver to stop surface run off. The bank of soft friable soil that builds up a terrace behind a row of Vetiver acts as blotting paper, sucking in and absorbing rain and holding it for months longer. Once established, every few months it is necessary to slash down the top growth of the Vetiver and use it as mulch spread out over the terrace below. See also my Trifinio paper.[74]

Machinery:

I have written plenty about processing machinery in other parts of this website, However I would like to suggest some more types of agricultural machinery to facilitate an organic reduced labour cost regime. First is a walk behind self propelled slasher[75], to keep the pintoi in control, and which will throw the slashings sideways to maintain a mulch layer under the trees. This means planting ones rows wide enough to get even a narrow machine down between the rows. And allow a mechanical harvester to straddle one row at a time. That will probably mean taking out every alternate row in a previously close planted system. But you also need that space to grow the pintoi. You may get a better price for an organic sustainable product but you will never get the same weight of coffee. Then, for attacking the tall growing shelter it's a case of finding a method to trim a hedge up to 6 metres high. For the initial development and growing stage of the shelter a hand held type will be ample.[76] But once past the 3 metre height there is lots of heavier commercial equipment in the temperate climate sector to choose from. The organic fundies make a lot of milage about providing lots of jobs, but the aspirations of every coffee labourer is to earn more money. That can only happen by retraining them as machine operators and maximizing their output and their earning potential by mechanization.
It also means using less rural labourers,. But those same skilled people can now afford to send their kids to school! For the mechanical harvesting of coffee there are also several options[77], the best originating from Toft bros in Australia, but now made all over South America.[78] The Korvan Harvester, now made by Oxbo[79] in the USA and Europe is also good.

For general husbandry, pruning fertilizing etc. and as a gradual step up to full mechanical harvesting there used to be the Tinkabe straddle tractor, made in Swaziland. A 20hp machine driven by hydraulic motors on each wheel, mounted on steerable legs and with a tray over the top. It would seem to me that such a platform with height adjustable legs and a boat shaped guard around the legs on each side, with a seat in the middle of each boat would allow pruning and spraying etc at a much greater pace and comfort. Part of the sustainable conservation picture has to have a sector which will

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[72] http://www.soilmatters.com.au/products/nitrogen-fixing-bacteria/twin-n.aspx
[73] http://www.idosi.org/wjas/wjas6(2)/13.pdf[73]

[74] http://www.coffee.20m.com/CoffeePropagation/Trifinio%20General%20Project%20Outline.pdf
[75] https://www.youtube.com/watch?v=H6dgUMh8SGA
[76] https://www.youtube.com/watch?v=koGTTiOA6YY
[77] http://dankuhncoffee.com/wp-content/uploads/2010/08/Coffee-Production-Aussie-Style.pdf
[78] http://www.ubras.com.au/Mechanical_harvesting.htm
[79] http://www.oxbocorp.com/OxboLocations.aspx

create the transition from large numbers of unskilled labour to less numbers of more highly paid and higher skilled staff. That Tinkabe tractor with room for the picking buckets ahead of t he pickers, seated high and low behind the boat shaped screens, with a radio playing in the background makes an ideal transition. A totally mechanized harvester as detailed in the previous paragraph is BIG bikkies!

The placement of shade trees, particularly Casuarina, requires a machine that can slice down into the soil and cut off shallow root systems that might encroach on the coffee. Behind the sharp vertical disc that slices through the top soil, create the facility for the vertical leg of a mole plough. That leg if required can pull a 50-75mm plug at a depth of around 700-800mms, to create a downhill drainage pattern before planting lines of Vetiver for terracing across the slope. That would be the old story of "killing two birds" with one stone.

Back onto Nitrogen:

The most important aspects of organic nitrogen production are ground cover and water retention. So much commercial coffee production used to run by overdosing with synthetic nitrogen and spraying out all the weeds to give zilch ground cover. In Papua New Guinea for instance there was a rule of thumb that went, no fertilizer and shade gave about 1 tonne of green bean per hectare, the typical small holder production rate . Cut out the shade and from then on, based on the years pricing forecast for beans and fertiliser, for every tonne of fertilizer, usually DAP, you could get an extra tonne of green bean production, up to 6 tonnes of fertilizer/Ha for 7 tonnes of bean. The problem was when the price fell one had to taper down slowly to avoid massive over bearing dieback, but a lot of people made a lot of money on that basis. However, placing soluble fertilizer on open ground meant a lot of surface runoff and waste of resources. The major reason for not repeating that kind of exercise is not only that you will forfeit organic status, but you will also severely knock the whole organic biological farming system.[80] [81] Plants are not silly. It costs them a lot of effort to get other organisms to fix nitrogen for them, and if they can get it from elsewhere, they will rapidly close down their own operation and use the free stuff. It then takes a lot of time and work to get them to pick it back up again.

How grows the Amazon rainforest:

Stories abound as to how local peasants are decimating the jungle to get only a few years of gardening before they end up with an infertile acid clay basement and have to move on to level more jungle leaving the cleared land to be only good for raising skinny cattle. The secret to the Amazon rainforests fertility[82] is the extremely rapid recycling of nutrients held up in an extremely thin layer of organic matter which retains everything, those big but very shallow buttress roots and all, in a shallow layer with no loss of nutrients down into the basement. Once that thin

[80] http://www.fao.org/wairdocs/ilri/x5488e/x5488e0e.htm
[81] http://www.agroforestry.net/the-overstory/272-overstory-257-biological-soil-fertility-management-for-tropical-tree-crop-agroforestry
[82] http://www.wildmadagascar.org/overview/rainforests2.html

layer is lost so is the fertility. See "terra preta"[83] for another solution. That's where the use of biochar comes in.[84] [85] [86] I have yet to find a burner that will burn coffee hulls for drying the coffee and also provide biochar to get a good organic soil. Join me in the search! We have to emulate rainforest soil conditions to grow organic coffee with less than half the rainfall. I have answered this problem for dry forest conditions in my above mentioned paper on the Trifinio country of Central America. By conserving moisture with Vetiver terracing and continuously side rowing lush green mulch under the coffee trees it is possible to keep a moist layer of rapidly decomposing organic matter under the shade of the coffee itself, much like rainforest conditions.

In Conclusion:

Turning a sun coffee plantation into a sustainable organic sun coffee plantation is far from quick and is expensive. However in this day and age it will give you not only superior prices for your product but also the accolades of the retail industry though maybe not the 'organic' purists. I also have a sneaking suspicion that planting wide enough to grow enough A.pintoi between the rows and getting a good depth of mulch layer under ones trees, one doesn't really need the shade??? But that's a thought that's beyond my actual experience. Have I seen all the sections and bits of the above scenario being done in various places YES! But all in one place and at one time? NO! But I hope that you will try. At 79 I am too old to try again myself. Write to me if you are willing to give it a go. I would just like to know. Nothing more than that. Adios!

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https://ecofriendlycoffee.org/role-of-fungi-in-coffee-plantation-ecology/
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[83] https://en.wikipedia.org/wiki/Terra_preta
[84] http://www.ithaka-journal.net/druckversionen/bc-guidelines.pdf
[85] http://environmentportal.in/files/Biochar%20in%20agriculture.pdf
[86] https://edis.ifas.ufl.edu/ss585