Charcoal at the bottom of your garden, anyone?

Geoff Moxham

How would you like to have the same fertility you've got in your best plot now, in 40 years … with a fraction of your back-breaking soil carbon inputs? Read on …

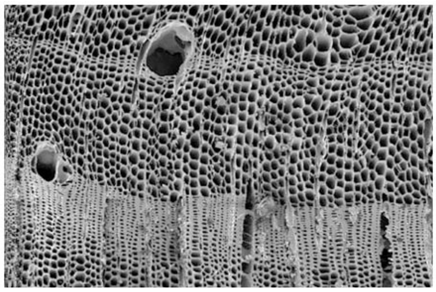
[Acknowledgement: I stand on the shoulders of hundreds of giants to bring you this, some of them > 1500 y.o. The best source of current data on agricultural charcoal and black carbon sequestration is the world terrapreta mailing list/forum at www.bioenergylist.com. The quotes here have essentially originated there. As Phala says in Kundun, "I am just a bug, holiness". GM]

I have been startled by how misunderstood ag charcoal is by some of the most talented Organic farmers around here. The horns of the dilemma seem to be the already high quality of good organic soils, and the time/$/fossil to add an "unknown", or: if we're already at 90% yield how can we get a 30% increase? The answer is obviously in the work we don't have to do in years 2, 3, and 4 ... there is a 40-year no input experiment still running in South America.

This point is eloquently addressed by Richard Haard: "Expectations — Spend some time in the literature and make comparisons to the soil conditions in Amazonia to your own. Do you currently have issues in your soil maintaining organic matter content, CEC, calcium and potassium availability, phosphorus binding, leaching of nitrates?

"If you add charcoal to your best soils you may have a muted response. This is our situation, and my way to work around this is to continuously crop with no further organic matter or fertilizer additives. We are now on second crop moving into second year of 3 or 4. An alternative for you would be to use depleted soil to start to study the effects of charcoal in combination with compost and or manure."[15]

There are other benefits as well, some listed by Sean K Barry: "Maybe we could convince OMRI [Organic Materials Review Institute] that charcoal is a substrate that enhances and improves the performance of the fertility management practices they already undertake. Charcoal can be promoted as a universal "carbon balancing" mix, a safe, ecology-promoting, soil mixture additive. If the current soil amendments they give their farmland, and the microorganisms it holds, are what these need to "hold" nutrients in the soil and "deliver" the nutrients to growing plants, then just add charcoal into that soil to improve that, and water it. [In other words this is your best practice inoculation process.] Charcoal in soil can loosen "tight" soils, giving it greater friability and tilth, which allows deeper water and root penetration. Charcoal in soil promotes the growth of humic acids and plant symbiotic organisms that help plants get nutrients from the soil. Charcoal in soil mixtures with your fertilizer can improve the resilience of that fertility which you work so hard to put into a garden. [Reduces leaching nutrients in wet season, and stores water and biota in drought, fallow.] It can help bring the nutrition from composted waste into the soil and to growing plants faster. Regardless of your fertility management practices, charcoal in soil can enhance the performance of those materials and help beneficial qualities in soil stay and renew themselves in your garden soil. [The "renewing effect" quality of TP (terra preta) may also be from TP-laden vermicast transported through the horizons by worms, hence the need for "fines"]



Scanning electron micrograph of pine (Pinus sp.) charcoal from Barton Creek Cave.

Photograph © Foundation for the Advancement of Mesoamerican Studies, Inc., (www.famsi.org). Author: Morehart, Christopher T, Plants of the Underworld: Ritual Plant Use in Ancient Maya Cave Ceremonies, 2002.

"Using charcoal amendments into soil is good for the environment and it is also one of the best things you can do to reduce the effects of Global Warming and Global Climate Change. It takes problematic carbon CO_2 directly out of the atmosphere."[16]

Now if you want to get deeply biological rather than technical, I am a materials and technology science-head, not a soil scientist, so I will quote Richard again:

"The best hypothesis to me is

that terrapreta must be enriched habitat for beneficial organisms that promote abundant soil biomass, and that conserve nutrients from leaching, just as does the forest canopy foliage in undisturbed forest.

"The mycelium of a saprophytic fungus that is decomposing lignin or cellulose is also food and habitat for the equivalent of plankton in the soil. Biomass itself is a stable, insoluble reserve for nitrogen, phosphorus and other nutrients. In the forest root zone, the rhizosphere, sugar exudates from the tree roots serve as food for the microbes that make this nutrient reservoir.

"Drought in any soil is the end of life cycle for billions of microbes and insects. In a fallow agricultural soil - between crops - there are no roots to capture these released nutrients. Terrapreta then, through physical attraction by charcoal and rapid microbial activity, must be the mode of nutrient conservation. As the simple substrate carbohydrates in the wood waste disappear, and the nutrients that are released in their decomposition flow into the charcoal, this habitat will become more attractive to species of fungi and bacteria that are either autotrophic or symbiotic with tree/crop roots.

"Where [the industry] is working now is pre-treatments that make charcoal rapidly attractive to these beneficial organisms. The dominant fungus we viewed was a species that came in with the conifer sawdust-based compost we purchase, and routinely use at our farm. It is a species of birds nest fungus, Nidularia, and it is a strictly saprophytic and not mycorrhizial partner. Next year in the same beds after the substrate degrades other fungus species may come into play which use the non - organic habitat of the charcoal and interact with crop plant roots. The fungi Larry found in his pretreated charcoal in his small vegetable bed were different. Also we spend quality time looking at every other kind of critter using charcoal as habitat, worms, saprophytic nematodes, insects, as this is an indication of charcoal becoming a sustainable ecosystem in itself."[17]

Locally, Lukas van Swieten, at the Wollongbar DPI soil research station is doing impressive field trials now[10]. You might have noticed Terania Creek's Josh on that Catalyst grab of the gas emission study.

The trials at Wollongbar and Cornell, show that char treated soils emit far less GHGs, especially the active ones like methane (28xCO_2) and nitrous oxide (300xCO_2). Just how much more carbon-negative char can become is still under scrutiny, by a wave of interest that looks like being as great as last century's development of fossil fertilisers[14]. There's some very bright sparks of hope here that may yet claim Branston's prize for sequestering a billion tons in a year. I wonder when someone will think to feed feedlot beef some char powder, grab all their methane and sequester the inoculated TP in each pat … any takers for research?

The best news is that the process downsizes to the backyard … you can pee on char, put compost juice on it, worm juice, put it in your composting toilet … the list and the number of permutations and combinations is impossibly long. And every location's colonising biota will be slightly different.

Composting with charcoal hasn't really had much of a consciously devoted following before "terra preta" hit the media, though there is evidence the practice has also been in Japanese agriculture for some time. Since char is just a high rise for what microbial life is already in the soil, it's how we do the processing of the char afterwards that is the hot area of research, right now. Compost juice for two weeks has been suggested. Char size up to 1cm has been shown to work, but finer is better. Inoculants will be a big business with companies like Eprida trying to say their ACOSS inoculation of the "coral reef" is better than … whoever's…[8, 12]

What also seems to be happening is an actual fight for the names and the proprietary rights etc (why aren't I surprised?…quiet vomit…). The International Agrichar Initiative changed its name to the International Biochar Initiative. I recommend their site: http://www.biochar-international.org/aboutbiochar/articlesonchar.html

IBI is an international collaboration to do R&D&D&D (and dissemination and deployment) urgently on Biochar, and the site has links to the best downloads.

Last year on the ABC's Catalyst[10], readers may have seen the aerial footage that only recently revealed the rows of cultivation, covering twice the area of the UK. This supported a huge population, the 'El Dorado' that historians had first thought Spanish explorer Francisco de Orellana had hallucinated in

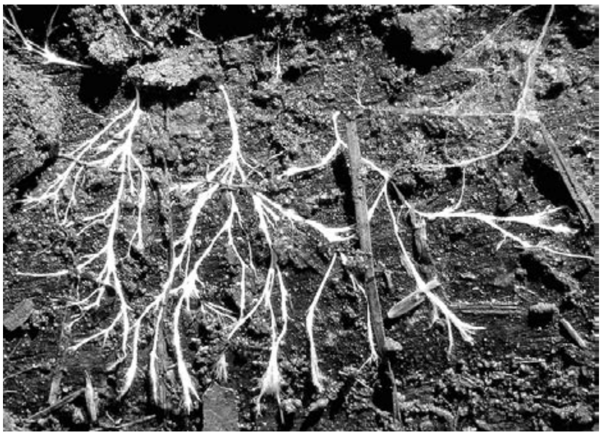
1542[13]. Remarkably, this soil is still fertile, and millions of tonnes of carbon appear to be genuinely sequestered as well, not just in a political fantasyland projection. Carbon dating is a rather well proven science, giving irrefutable proof of sequestration that even The Lying Rodent himself couldn't argue away.

But how can we ever know the real truth of how the Amazonians were doing it?

The answer is it doesn't matter. Although we can't really know how the south Americans processed terra preta due to lack of historical records, but the char is the same, apart from the species of woody material. That the charcoal is still there, is evidence that the fires were intentionally extinguished before the carbon started to burn, just like the charcoal burners for the blacksmiths of Europe, and the Catalan forges of the Middle East. Presumably a shallow row-pit and smothering could combine with plowing energies, but water could have been used.

This is a wonderful example of do local and think global. Rob Klein's stover theory (TP list) has it that an Amazon technique used corn stovers (dried stalk and rootball) built into a large, high heap, with the roots outermost, mudded up, and fired from the top with glowing charcoal. This would explain the low-fired pottery shards found along with charcoal in terrapreta. As country dwellers know, large, hot burn-offs kill the biota immediately below for a long time, even though there is a fertile edge effect. So separate cool-burn sites will be kinder, and would make carbon-negative heat and power as byproducts[7].

Locally, Peter Hardwick has started biochar experiments at Djanbung Gardens, using dried lantana and crofton stalks, and Dr Keith Bolton intends to char his agricultural hemp waste, and reuse it. The way forward is to make your own from your own woody waste. This same waste, if composted, would return to the atmosphere as CO_2 within about 3 years, whereas biochar sequesters 30-50% for thousands of years. The triple whammy of being a fertiliser, a long term carbon sequestration, and a renewable fuel qualifies it for Permaculture's triple use bottom line, hence David Holmgren and others interest, it also explains the glowing opening address by Tim Flannery at the first International Biochar conference at Terrigal last year.



Hyphae as seen under an overturned log.[18]

Terrapreta's top researcher, Cornell's Johannes Lehmann has also estimated that on a massive scale, adopted globally, the process could begin to drive the atmospheric CO_2 concentration downwards by 2030, without risk, unlike the escape potential for liquefied CO_2 geosequestration. [Each person sequesters >one tonne/y[1,2,3]]

Charcoal is so completely safe it is used orally in hospital emergency for VOC ingestion, poisons that can't use an emetic, snakebite etc. The health industry prescribes it for detoxification and flatulence … there's that cow inspiration.

So if you want the fairies at the bottom of your garden to stay there and a not be replaced each year by someone else's fairies, inoculate your own charcoal with your own best practice rhizosphere biota, and put them there for your grandkids kids.

Next GO I will try to detail 4 good ways to make charcoal on the farm or in the firebox. Start collecting old 44s and don't burn ANYTHING. Part 3 will be on methods of inoculation. I will leave you with the final word from SKB:

"Terra Preta researchers using scanning electron micrographs have shown "hyphae grown by vesicular arbuscular mycorrhizal (VAM) fungi permeating and growing through the pores of charcoal in soil.

The VAM fungi grow hyphae to serve plants in a symbiotic fashion. These are hollow tubes that the fungi attach to the hairs of roots, which extend penetration into the soil and deliver water-soluble nutrients to the plants. The fungi grow the hyphae in exchange for (the symbiosis relationship) and using the energy from sugars provided by the roots of the above ground plants. The hyphae are covered with a sticky sheath, called "glomulin". When the hyphae die, the glomulin is left in the soil. The glomulin binds up water-soluble nutrients and forms "aggregates" in the soil. This is the mechanism that is believed to be responsible for the nutrient holding capacity of TP soil.

When charcoal is made from biomass, most, if not all of the inorganic plant nutrients that were in the original plants are retained in the ash portion of the charcoal (calcium, phosphorus, iron, magnesium, etc). They do not burn off or exit the pyrolysis reaction as gases. So, in fact, charcoal from biomass, has nearly all of the same fertility enhancing nutrient content as composted biomass (save for nitrogen). But, the carbon in charcoal will not gas off like the carbon in carbohydrates in compost. Charcoal in soil does not emit CO_2 like compost does".

Lotsalove

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18. by TheAlphaWolf http://commons.wikimedia.org/wiki/Image:Hyphae.JPG

Making Charcoal for Agriculture - 101

Geoff Moxham

Rule 1: Use Dry Feedstock. Drying wet wood uses much more energy during pyrolysis, and makes dioxins aplenty.

Rule 2: Don't Make Smoke. Smoke also contains methane, which is very greenhouse positive, and pyrolysis gases are toxic. A tarry smell indicates poor agricultural charcoal, due to incomplete pyrolysis, called torrefaction. 'Torrefying terminology!' Smoke also annoys neighbours and the EPA, and that smoke is fuel value you're not getting.

Rule 3: Control The Air. To stop smoke, add air, or feed fuel slowly. This applies to your space heaters and fuel stoves. To stop smoke very intelligently, arrange things so that it is directed at the high temperature zone of the reactor fire.

Efficient burning with lots of air destroys all the toxic VOCs (volatile organic compounds) in the gases from wood. In a good reactor, these gases will provide 20% more useable heat (for power, or drying), on top of the heat needed to pyrolise the load and produce charcoal.

To stop air destroying your hard-won charcoal (devastating, I can tell you) you must have reasonable seals, for the load to cool without air.

That's all there is to it … almost … you might like to set up systems to solar dry the feedstock for a year, to bring it to a dry storage area, a cutting area, a batch loading area, a state of the art pyrolising area, a process-heat drying-area, a char pulverizing area, an inoculating area, and finally dispatch to the spreader. Not much. The thing is… it's going to be worth it.

Climate Skeptics' Notes

For those economic rationalists expecting "business as usual" and "market forces to prevail" — agrichar still has the best prospects for sustainable bottom line reasons alone.

- In a recent agricultural trial at Wollongbar DPI research station, corn grown with agrichar amendments, outperformed all conventional agricultural amendments
- agrichar gives resilience to drought and wet
- agrichar establishes a set-and-forget reserve of soil carbon, that ensures the family farm is passed on in better condition and with guaranteed longevity
- co-generation of remote power is possible with woodgas gensets,
- Process heat can be used to dry crops, heat water, dry wood/ feedstock.

So if you don't believe in anthropogenicly forced CO_2, and CH_4, nor care about your neighbours, nor your family's health, nor care about your yield for your work … in fact if you just want to fool around and make some char, if badly, here are my ratings out of ten for the old methods, arranged, worst first:

1/10 – open burned trees in windrows, wet, usually fired many times. (yield = 0 - 5%) carbon positive, dioxins, stoopid.

2/10 – "the cigar method", timber pushed into trenches, covered with soil and lit one end and smouldered for weeks. (5-20%), nasty, archaic, torrefaction, dioxin. C positive.

3/10 – piles of light weedy waste (lantana?), dried to a crisp, and fired on the ground with little smoke, and quenching with water. (20 - 25%) simple, but lye fills char, some torrefaction. Carbon neutral.

4/10 – dedicated burning bay with waterproof floor, dry fuel quenched with water. (25%) less loss to ground but lye again fills char interstices, and slows down the inhabiting organisms, torrefaction. C neutral.

5/10 – open topped drum with airtight lid, with dry, slow feed, no smoke and snuffing when red coals are reached, using lid and bottom vent plugs. (30%) almost passes, but still lossy, easily re-ignites, still some torrefaction. C- neutral.

Carbon Negative Farmers' Notes:

If you plan to sequester charcoal, take notes and photos, keep receipts and record results, as there is a good chance you can join the queue to apply to the IPCC panel for carbon sequestration credits. There is an agrichar report being prepared now, and European research and production preparation is quite advanced and extensive. A Queensland company is prepared: http://www.ecocarbons.com/Carbon%20Trading.pdf

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Good ways to make charcoal in the firebox and on the farm

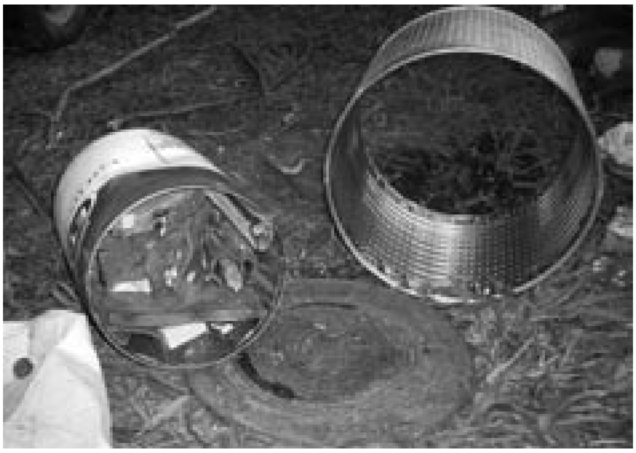
Pic 1. Up to 300g: Small tins in a woodstove. These are two tins that fit tightly over each other, after one end is taken out of each tin. A hole is punched in one tin with a 3” nail.

Pic 2. They go in any firebox, but a glass front is useful. Firing time ~1.3 hours, finishes after the yellow spout of flame ends. Kids love it. Great for testing feedstocks. Get tongs and leather gauntlets.

Pic 3. 300-500g: My big “Hearthy-BlastFast” T-LUD Woodgas stove, made from a honey half tin, has fan-forced secondary air from a computer fan. A pyroliser insert makes a carbon negative cooker, for sequestering charcoal after the cooking is finished.

Pic 4. 500g-1kg: Pineapple juice tins that fit inside 20 litre drums are the next size up. A convivial size for demonstrations, fire irons and a billy.

Pic 5. 3-6 kg: Stainless Fisher & Paykel drum provides lots of secondary air with all those holes, and is a good size for a 20 litre paint tin retort. This unit makes a great carbon-negative space heater, and more than a ‘one-person-day’ CO_2 footprint’s worth of charcoal for sequestration.



Pic 6. Components for the Guenther inverted-drum technique, including base plate and 20-litre drum charged with wood. Smaller fuel size is better, less than 50mm is best.

Pic 7. The primary fire has to be kept going for the whole firing by adding small amounts of stick-wood regularly, (for about 2 hours). Preparation! Intensive work! Hence the next obvious step … a dragon kiln.

Pic 8. The woodgas lights up and burns vigorously for 30 minutes or more. The primary fire is kept going for another 30 minutes, after the last woodgas flames are visible, to ensure all the gases are driven off. Yield is >40% of EMC weight. This is the basic unit to replicate for a Jagama-style climbing kiln. Insulation and walls raise efficiency, and are up to you.

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The same company is set to use a BEST pyroliser in Gunnedah for cogeneration and char. (There is no mention yet of reversing the “burp tax” proposal on ruminants, but if char is used to absorb methane, there is a third possible saving there.)

On the farm and at home

If you start making charcoal using closed drum retorts (opposite), you can get the ideas sorted in your head, start very small, test your samples of feedstock, and then progress to larger systems. Just follow the steps.

The importance of air

The air supply to a pyroliser is usually divided into primary and secondary air. The primary air supplies the initial fire that heats the charge of wood. Secondary air is extra air supplied to burn all the off-gases completely to CO_2. “Dry” wood at equilibrium moisture content (EMC) is about 15% water, 40% char and 45% volatiles, depending on species. At high temperatures, the water acts as a fuel, as it reacts with incandescent carbon and makes “producer gas”, H_2 and CO, which then burns to H_2O and CO_2, with the secondary air.

The inverted drum break-through

Just weeks ago, Folke Guenther on the terrapreta list at bioenergylists, found a simple vast improvement to the drum firing technique; done by simply inverting the drum full of wood over a stable, flat base-plate. The weight of the drum holds the rim with a good enough seal to let the gases out, in a neat ring of fire, that washes over the reactor. The seal is good enough to not let air enter in the cooling stage. A second, very aerated drum with both ends removed, is placed on standoffs, around the upturned smaller drum, and the primary fire is set in the annular gap between the two drums (see opp.) The process can be scaled up greatly, and a similar system is running in Russia with 20 tonne loads in 10 vessels manipulated by gantrys!

Several inverted 20-litre drum units can be stacked up a slope, on platforms linked by a tunnel, like the version of climbing kiln called the Jagama, or dragon kiln, a multi-chambered climbing kiln of 17th century Japan. “Jagama are tube shaped similarly to anagama kilns, but they can be very long — 200’ (60 m) is not unreasonable.” http://en.wikipedia.org/wiki/Anagama_kiln. This added saving of the heat from each chamber, helps the firing of the successive chamber, and dries the whole tunnel. It makes this probably the most efficient, batchable, scaleable design for small farm use. I am currently building one, in fibrecrete and steel.

Thanks for your attention.
In fun,

Prof Pyro

Processing and Inoculating Charcoal for Agriculture

Geoff Moxham

Update:

This biochar stuff is a can of worms (ha). The original terrapreta list has succumbed to a factional split since June '08, following battles between all kinds of climate deniers, NPK freaks, vegan extremists and tree-huggers. The international "practical" forum has now moved to: Yahoo Biochar Group, and the "philosophical" forum to Yahoo Biochar-climatechange Group, the former posting at 10x the latter rate…

Whether you've found your charcoal in your fireplace each morning, or by intentionally making batches of it, you will get your best first-application results by crushing it finely and inoculating it. Crushing smaller than 10mm is recommended, these fines being easily transported in all directions by worms and other biota.

So far I have seen 3 practical methods suggested for grinding useful quantities, all preferring wet charcoal to minimize inhalation of dust. Corn grinders efficiently make a very fine "gunpowder grade" char dust, and only work with dry charcoal. After making just 3 kg that way, I required a hot shower.

1 For small test quantities, first try wet char in a coarse meat grinder. Adding bicycle power, or a 12V motor could vastly improve production rates. This may be the best, quietest, carbon-neutral solution for small gardens.

2 A bigger batch grinding process is to throw wet charcoal into a dedicated grinding "pit" or "bay", and run the mower over it. It takes just a few seconds, in my

experience. Don't do this with dry charcoal! This is a very fast way, and I s'pose if you can get an electric mower running on your panels it could even be sustainable, post oil, for a while. Controlling 'splatter' might be important if you add a rank inoculant.

3 For higher processing rates you can use an insinkerator/garbage disposal system. This is a cheap accessible way that also allows good inoculation with liquids like biological "teas", and missing trace elements. These can be added drip-wise, as the mix is processed directly into holding or brewing tanks, for 10-14 days. I have set up a grinding system like this using an old sink and a re-purposed $10 insinkerator. You can hopper-feed the unit at a rate giving the desired reduction, or for very fine grinds, return the drain in a loop to the tub, using 2" gate valves and a Tee. This suits small and large farms using grid power, and capable of spreading slurries.

I could claim a 4th method but it's just the 2nd, scaled up: It uses a tractor-slasher in a large bay of sleepers or logs. This is a small-scale commercial method that could produce tonnes per day, if the feedstock existed. Both mower and tractor versions can be finessed with wooden shutters, guides and grates, and a second operator feeding the fossil monster with a front bucket.

The 5th column? I can see an opening for a creative farm engineer to build a char hopper and inoculation drip onto a slasher, and do the whole thing with one pass/ slash, inoculate, grind, spread, (+ biochar is a lime-equivalent) … go on make my day, make a fortune, and give 1% to CCAN.

So what exactly is the inoculant? THE billion-dollar question. All I can say is: your site decides. Left to itself, the char dust will take up the local biota signature, which would be ideal for native plants and regeneration. In your best garden patch it will take up the biota population that is currently doing the work. But everyone wants it speeded up. At the moment the discussion is either about adding char to NPK fertiliser applications in mainstream "agro"culture, or making various creative teas from urine, worm juice, compost percolation, and brewed, crop-specific teas. Home inoculation in a plastic barrel for 2 weeks seems to be a common convivial suggestion … so be part of this rather rapidly rising meme and try your own experiments … feed your results to the world through the web … while we still have it.

There is a very promising synergy here with existing bio-tea brewers, and fertiliser processors, and I'm guessing, by the deafening silence, that there are quite a few non-disclosure clauses out there, creating enormous cognitive dissonance in people of very good heart, as we barrel over the resource lemming-cliff. So come to the organic market and spill your beans.

Cheers, Geoff.

Health alert-not-alarm:

Some charcoal dusts like rice husk and bamboo can contain silica, so minimise by wet grinding. All inoculating makes splashes and aerosols somewhere, so take reasonable precautions.

Nardi, a scientist at the University of Illinois, writes in his newly published book, "Life in the Soil," that a square meter of healthy garden soil is home to 10 trillion bacteria, 10 billion protozoa, 5 million nematodes, 100,000 mites, 50,000 springtails, 10,000 creatures called rotifers and tardigrades, 5,000 insects and arachnids, 3,000 worms and 100 snails and slugs. Throw in the occasional mammal such as a chipmunk or a mole, and a salamander or two, and you get the idea that you don't have to travel to the Brazilian rainforest to luxuriate in the biodiversity at our feet.