

Manjimup farmer Doug Pow has boosted productivity, reduced inputs and methane emissions, and so much more ...

profile

Doug Pow
Manjimup

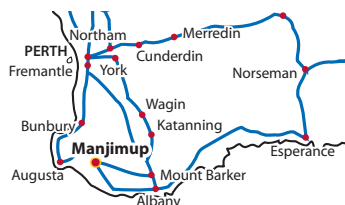
Farming system

Area: 53 ha

Rainfall: 1000 mm historically
(800 mm recently)

Enterprises: Beef and avocados

Soil types: mix of heavy vertisol clay flats, medium red to brown chromosols, lighter red to brown kandosols and some lateritic gravel.



Whole-farm **biochar** system boosts productivity, stores carbon, cuts inputs and emissions

Lauren Celenza, WANTFA Extension Manager

Manjimup farmer Doug Pow has discovered how to store carbon in the soil, reduce methane emissions from his cattle and improve the productivity of his whole farm.

The cattle and avocado producer started feeding his cows biochar five years ago to see if he could store carbon in the ground using the natural system of dung beetles. He thought if researchers were burying biochar in the ground with machines in an attempt to store carbon and increase fertility, why couldn't the dung beetles do it at no cost?

He already had the cows, and knew the beetles would bury their dung within a day or so, to around 600 mm deep. He thought he would be onto something magnificent if he could feed biochar to the cows and have the beetles actually bury it.

Not only was he right, but it had unintentional side effects that had far greater importance than he ever imagined. He has boosted productivity, reduced inputs and methane emissions, and so much more.

GROWER EXPERIENCES

'The purpose was initially to prove one thing, and that was proven within a couple of days: we created a system of delivering biochar into the ground, using cows and beetles,' Doug said.

Since then Doug has been continuing to feed his cattle biochar and monitor its effects, and has more recently planted new avocado trees with biochar, which has had its own significant benefits.

What's more, Doug has stopped feeding his cattle hay, stopped producing hay and stopped using fertiliser on pastures, potentially saving him millions of dollars.

So with very little investment, Doug has transformed his farm into a highly productive, low emitting ecosystem of plants, animals, bugs, fungi and microbes, and says this principle can be applied on a grand scale and altered to virtually any farm or area.

How to feed cows biochar...

Surprisingly, it's not difficult to train a cow to eat something they don't normally eat. Rewarding them with something sweet is how Doug gets his stock to eat biochar, mixing it with molasses or glycerine and presenting it in a feed trough or bucket. Doug said the cows will eat a few mouthfuls and then move onto pasture, allowing others to ingest the sweet black sludge, regardless of their ranking in the herd.

Doug feeds approximately 300g of biochar per cow per day. This figure was developed from research into intensive dairy operations in Germany to reduce diseases caused by housing, hard floors and ammonia being released from the dung.

'Once the dung has the incorporation of biochar into it, it seems to absorb a lot of the nitrogen and doesn't volatilise into ammonia, which is what causes the health problems, but luckily the lack of smell hasn't deterred the dung beetles,' Doug said.

Effect on the cow

The effect of this practice on the cow has been positive so far, and despite having biochar in their stomach, displacing room for feed, the cows were getting fatter and healthier.

'Methane burped out of the cow is energy wasted, but it appears the pore spaces in the biochar creates a harbouring arrangement for methanotrophic bacteria that use methane as a feed source,' Doug said.

These bacteria are naturally occurring in Doug's soils and are picked up by the cattle as they graze the pastures. According to international research, these bacteria reduce the amount of methane that is burped out.

'We haven't tested our cows in plastic bags or chambers but it seems if they are getting more energy from less food, and producing more meat, so that's probably the reason,' he said.

Influence on soil ecosystem

The biochar-dung beetle system has had a profound influence on soil fertility and has created an ecosystem of bacteria and fungi, beneficial to everything it reaches. Doug said it's the change to the soil that is ongoing and permanent. His cattle are now eating massive amounts of clover as soil fertility improves and promotes legume growth.

'The cow is getting more nitrogen in its diet from the extra legumes and that's enhancing the effectiveness of the biochar,' Doug said.

Soil health improvements from biochar include increased nutrient retention, reduced leaching, increased cation exchange capacity, improved soil structure and water-holding capacity, decreased soil acidity and increased numbers of



The biochar experiment started with the cows, feeding it purely as a test to see if, for almost no money, Doug could use two animals to sequester carbon into the ground. Not only does the cow and the beetle combination enhance the biochar but it's being dug very deep into the ground.

microbes. It also can reduce fertiliser requirements without affecting the crop, or increase crop yields with less fertiliser, however benefits vary depending on the type of biochar and soils (Brockman 2015).

Doug has created a fascinating system; the cow drops the dung, the beetles fly in for about 30 minutes each day and process the dung by sucking out the water and burying the bulk (including biochar) deep in the ground, then the beetles fly away. After several days, grass starts to come up and everything starts to grow, a profusion of earthworms and fungal growth appears, which then dies off around the time the cows come back to feed over it again.

From the work that's been done on Doug's farm, he said clay in his soils was crucial to the results.

'It's a reactive clay, and mixed with the biochar and the nanoparticle-sized magnetic iron that we have in our soils, it allows the biochar:clay:iron matrix to become an electrical conductive medium in the soil,' Doug said.

'That's allowing an electron shuttle process to occur and it's moving elements from the minerals to the plant that the plant couldn't access without the matrix.

Doug is not fertilising each year now as the plant roots are growing to a greater depth and accessing more minerals than before. The process is also freeing up phosphorous and potash in the soil that has previously been unavailable to plants.



With very little investment, Doug has transformed his farm into a highly productive, low emitting ecosystem of plants, animals, bugs, fungi and microbes.



Carbon sequestration a profitable system

The original thing Doug was trying to test was if he could biologically reposition biochar in the ground as a way of sequestering carbon in an inexpensive and easy way and he succeeded in doing that quickly.

Biochar is a stable, carbon-rich form of charcoal that can be applied to increase soil organic carbon. It is produced by pyrolysis, a process where plant or animal waste is heated at 250°C or more with minimal oxygen. Biochar can reduce carbon dioxide (CO₂) in the atmosphere as pyrolysis traps the carbon in the biochar, which otherwise would have been released through decomposition or burning of plant material. Biochar is stable in soils and, depending on the type of source material, can remain in soils for hundreds to thousands of years (Brockman 2015).

While the cascading series of side effects have become far more important to him, Doug said sequestering carbon was something all farmers should consider, to not only improve farm health, but to potentially make money on carbon credits in the future.

Also, as biochar is a by-product from agricultural industries, Doug said it can be made at a profit because its production creates power from heat and it can be sold to others.

'Every stage of the process is profitable, and then there is scope for making money from carbon credits,' Doug said.

'We will be able to actively take CO₂ out of the atmosphere. 'It's cheaper to reduce other people's CO₂ than try and get them to do it, and if we can do it profitably at every stage from making the biochar, making the animals grow faster and healthier, and making the ground more fertile, we would be mugs not to do that.'

Why sequester carbon?

One of the most effective ways of dealing with human-induced climate change is to reduce the emissions of greenhouse gases. This treats the direct cause and there are various options available for this including reducing energy usage, renewable energy and carbon storage (Emissions reduction options 2010).

Carbon sequestration is the general term used for the capture and storage of carbon dioxide. Sequestering CO₂ in soil is an effective method as soils have an enormous carbon storage capacity and with changes in management practices, could be a significant store of atmospheric CO₂. Biochar is a promising approach to increase soil organic carbon, which is the subject of numerous current studies to increase the soil carbon sink. Biochar is chemically stable and the carbon can remain in the soil for hundreds to thousands of years (Biochar for agronomic improvement fact sheet 2010).

The beetles

There are copious amounts of dung beetle species, and each has their own characteristics and capabilities based on their original environment. Australian beetles are not suitable for cow dung as they target native species and are not attuned to bovine manure. There are also different types of dung beetles for different seasons and climates.

The first beetle that Doug began using was the *Bubas bison*. This winter beetle was introduced from Spain and released by the CSIRO decades ago and is now widespread in WA.

Doug said the *Bubas bison* was suitable for processing cow dung on Australian farms because it did not venture into bush and was no threat to any native fauna. It was also introduced with predatory mites which



The dung beetles process the cow paddies quickly and bury it deep, usually 600 mm underground, along with biochar that was ingested by the cow. Pictured is the winter beetle, *Bubas bison*.

piggyback on the beetle and eat fly larvae in the dung. A beetle species Doug has brought in recently, *Copris hispanus*, is very widespread in Europe and is assured to thrive across southern Australia.

'We are bringing in more colonies after this summer and are letting them go on other farms,' Doug said.

There is a gap in the year with low beetle activity, and Doug said they need to introduce a spring beetle, and maybe another autumn one to boost dung management.

Climate change + biochar = more money in the bank

Over the past few years, Doug worked out where all his money was being spent, and bravely decided to see what would happen if he cut out many practices including fertilising pastures, drenching cattle and feeding hay.

He said many practices farmers did each year were climate driven, and while the climate had changed markedly in the past two decades in the south-west, those practices remained.

'I didn't realise how much I was wasting on inputs like hay, fertiliser and drenches until I stopped using them—and nothing happened,' Doug said.

Doug said most cattle producers in the area would feed 3.5 roles of hay per cow/calf per year, at a cost of about \$75 per bail.

'We feed the cattle biochar which, for a herd of 60 cows, costs \$1000 a year, so other than our NLIS tags, that's basically our cost of producing cattle,' Doug said.

'If you don't feed hay, you don't need the tractor, mower, bailer, rake, time, labour—and when you start adding all that up, it's a lot,' he said.

Not long after starting the biochar experiment, Doug also stopped drenching cattle and fertilising his pastures; the cattle didn't get sick and it improved the soil's ecology even further.

Budgets

The following is a simple comparison between standard beef management and biochar beef management on Doug's farm.

Assumptions:

- Number of cow/calf breeding units are the same per area (60 cows per 40 ha).
- Pasture is the same mix of perennial and annual.
- Topography is the same proportion of summer dry hills and summer moist flats.
- Same paddock sizes, soil types and water requirements.
- Rotational grazing is similarly practiced.
- Animal breed and ages are the same.
- Calving:
 - Traditional beef farming calves in January/February and sell calves in November/December.
 - Biochar farming calves in July/August and sells half calves in June and half in December.
- Value of both cow herds is equal.
 - Traditional beef sells 60 calves at \$900 for \$54,000.
 - Biochar beef sells 30 calves at \$750 and 30 calves at \$900 for \$49,500.

Three scenarios of input for traditional beef raising

Buying in hay	Profit	Loss
Four 400 kg rolls per cow calf unit at \$75 plus delivery		\$18,000
Fertiliser applied (pasture) 40 ha at 250 kg per ha super phosphate:potash 3:1		\$5210
One nematode worm drench per cow		\$600
One pasture insect spray		\$500
Residual fertiliser value in imported hay rolls at \$10/roll	\$2400	
Total cost		\$21,910
Income	\$54,000	
Gross Margin	\$32,090	

Contractor making hay on beef farm	Profit	Loss
Four 400 kg rolls per cow at \$55 (contractors, labour and machinery)		\$13,200
Fertiliser applied (pasture)		\$5210
Fertiliser applied (hay) 20 ha at 100 kg N:K		\$1420
Cattle drench		\$600
Pasture insect spray		\$500
Total cost		\$20,930
Income	\$54,000	
Gross Margin	\$33,070	

Farmer making own hay	Profit	Loss
Four 400 kg rolls per cow at \$35		\$8400
Fertiliser (pasture)		\$5210
Fertiliser (hay)		\$1420
Drench		\$600
Pasture insect spray		\$500
Equipment depreciation maintenance and running costs		\$3000
Total cost		\$19,130
Income	\$54,000	
Gross Margin	\$34,870	



Biochar beef farming

Biochar beef farming	Profit	Loss
No hay made, purchased or fed		0
No worm drench		0
No pasture spray		0
No fertiliser purchased, freighted or spread		0
Biochar and sweetener \$1000		\$1000
Total cost		\$1000
Income	\$49,500	
Gross Margin	\$48,500	

As demonstrated in the tables, the difference when using biochar instead of traditional beef raising was an extra \$13,630 income. Also fertiliser amounts applied and costs in the traditional system were only to maintain soil nutrient levels, not increase them, while four years of Doug’s ‘biochar with beetles’ farming system has seen significant increases in available soil nutrient levels.

Doug said in order to value productive grazing land several parameters needed to be taken into account including extensive soil testing, stocking rate, profitability and the effort needed to undertake each task.

‘Biochar farming could also increase land value progressively, if the process and results continue,’ Doug said.

The avocados

Interestingly, Doug actually started the avocado industry in WA, 35 years ago. He now has 800 trees and WA’s industry is booming. More recently, after seeing his soils benefit from biochar, he has planted his new avocado trees on tilled topsoil mixed with biochar as part of a funded trial with South West Catchment Council (SWCC).

‘There is a lot of scope to improve avocado growing, without just planting on more land,’ Doug said.

Avocados are a crop which need irrigation and abundant fertiliser to produce. They have a low salt tolerance and a very high requirement of oxygen and boron in the soil.

‘They come from a volcanic andosol, which is extremely new soil derived from volcanic ash, different from any soil in the world,’ Doug said.

‘We are trying to chemically get the soil similar to that which they evolved in, and biochar assists that.’



Avocados evolved in volcanic andosols, like this one on the slopes of Mount Etna, Italy. Doug said the soil looks similar to WA’s pea gravel, however the particles float on water.

Method

Doug’s trial with the SWCC is to see how the avocado trees would grow with the addition of biochar in the soil. They buried 24 tonnes of biochar along a 200m row, with high and low rates to test upper and lower limits.

They peeled 300 mm of topsoil straight off the surface with a road grader, then took another 300 mm off and then deep ripped and rotary hoed it. Following that they applied the topsoil back onto the surface and mixed in biochar at different rates.

After mixing different volumes around 600 mm deep they planted young avocado trees on the soft soil, keeping a control row using current practice methods of just ripping and grading the soil into a ridge.



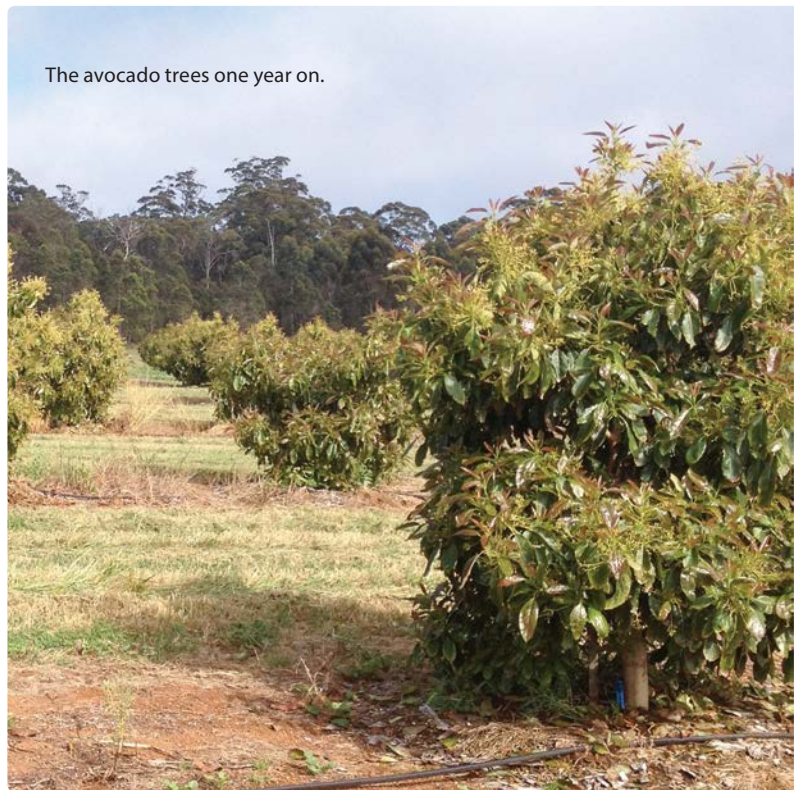
‘Everyone who comes to see this won’t plant an avocado tree without biochar now—the difference is that convincing,’ Doug said.

Leaf tests also show the biochar is also somehow reducing the amount of chloride the trees take on from irrigation water.

‘I’m changing the physical structure of the soil, and for a plant that grows for 50 years, you’d want it in a good base to begin with,’ Doug said. ‘Biochar is not expensive and it’s not like a fertiliser that is gone each year, it’s in there for thousands of years.’

‘We are trying to set up an even, natural system. They are huge trees; some will set 300–400 fruit a year when they are 4 years old. If every tree did that, that would be 25 t/ha and that’s \$150,000 a hectare.’

The avocado trees one year on.



What’s next?

While Doug continues monitoring and evaluating results from his beef:beetle:biochar system, he is also looking at growing tagasaste as an economical cattle fodder shrub. Doug is collaborating with Geraldton Department of Agriculture and Food researcher Paul Blackwell to see if having tagasaste available for cattle to graze from February to March will fill the feed gap being created by late season breaks that are becoming more common.

‘Tagasaste normally grows on deep sands in west midlands but there are plenty of deep sands down here and I think it would grow really well,’ Doug said.

‘It’s highly nutritious and if you can get animals something green when they wouldn’t otherwise get it, they will grow even more.’

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Disclaimer: More detailed research needs to be undertaken to evaluate a range of soil types, using different biochar types, biochar/molasses ratios, and dosage rates and dung beetles species. There is a need to analyse accurately costs and benefits to the farmer and also the feasibility of this method for long-term sequestration of C into soils. Further tests need to be carried out to determine if there are any residual toxins, such as polycyclic aromatic hydrocarbons or dioxins, which have accumulated in the meat of the cattle (Joseph *et al.* 2015).

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