A Comparison of Biodynamic and Conventionally Managed Soils – Hyden Western Australia

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INTRODUCTION

This article is an extract from a final year Investigation Project by Eric Frescher as part of the completion of a Bachelor of Civil Engineering at La Trobe University, Bendigo, Victoria. The Investigation Project Report was titled, "Dry Land Salinity Its Cause, Extent, Implications & Solutions" and was wide ranging as the title suggests. The investigation addressed the fundamental problems of dryland salinity and land degradation in contemporary Australia and presented solutions through the adoption of existing, best management sustainable farming practices.

The site for experimentation was chosen as a result of a letter published in "Living Agriculture" (Podolinsky, 2000) by John and Bernadette Cashmore, which displayed two sets of DOLA aerial photographs and a claim that biodynamic agricultural farming practice had assisted in the amelioration of salt scalds on their property, "Nyonger".

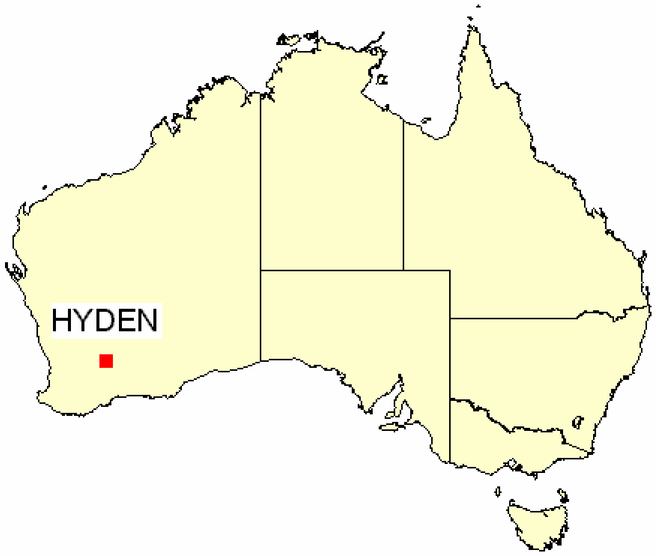
The principle purpose of the field investigation was to test John Cashmore's claim using a standard suite of field measurements. The aim was to field test as many variables as possible within the time and budget constraints. The claim relied on the independent comparative sets of coloured aerial DOLA photographs taken in 1994 and 1999 showing comparative salt scalding and John Cashmore's observations. Two case studies were conducted on the property.

The first case study was conducted in order to assess and then compare the relative effects on the soil profile (if any) of biodynamic and conventional farming practices; the outcome of which it was thought may assist in an understanding of the second case study which focussed on the original claim. "Nyonger" is located 40 kilometers east of Hyden in the cereal growing region of Western Australia as shown on the map.

1 CASE STUDY SITES

The first and second case study sites are shown on the 1994 DOLA aerial photograph as shown in figure 2.

The test sites, biodynamic test site 1 (BD) and conventional test site 2 (CV), were chosen by John Cashmore, at the writers request, for their similar soil type and land management history.



In addition, site 1 and 2 were watered by John Cashmore under instruction, on two separate occasions prior to testing, to activate biological activity and increase respiration which was to be measured. The wetting was necessary since the area was in a year of a severe drought. i.e. both sites received two waterings of 25 millimetres (total of 50 mm) 4 and 10 days prior to the tests commencing. Hence testing could be conducted for both wet and dry conditions at both sites. Figure 1 shows Eric Frescher conducting field measurement at site 1.

Figure 1 showing Eric Frescher taking measurements with helpers, in his field laboratory. Note the stunted form of the barley in these drought conditions.

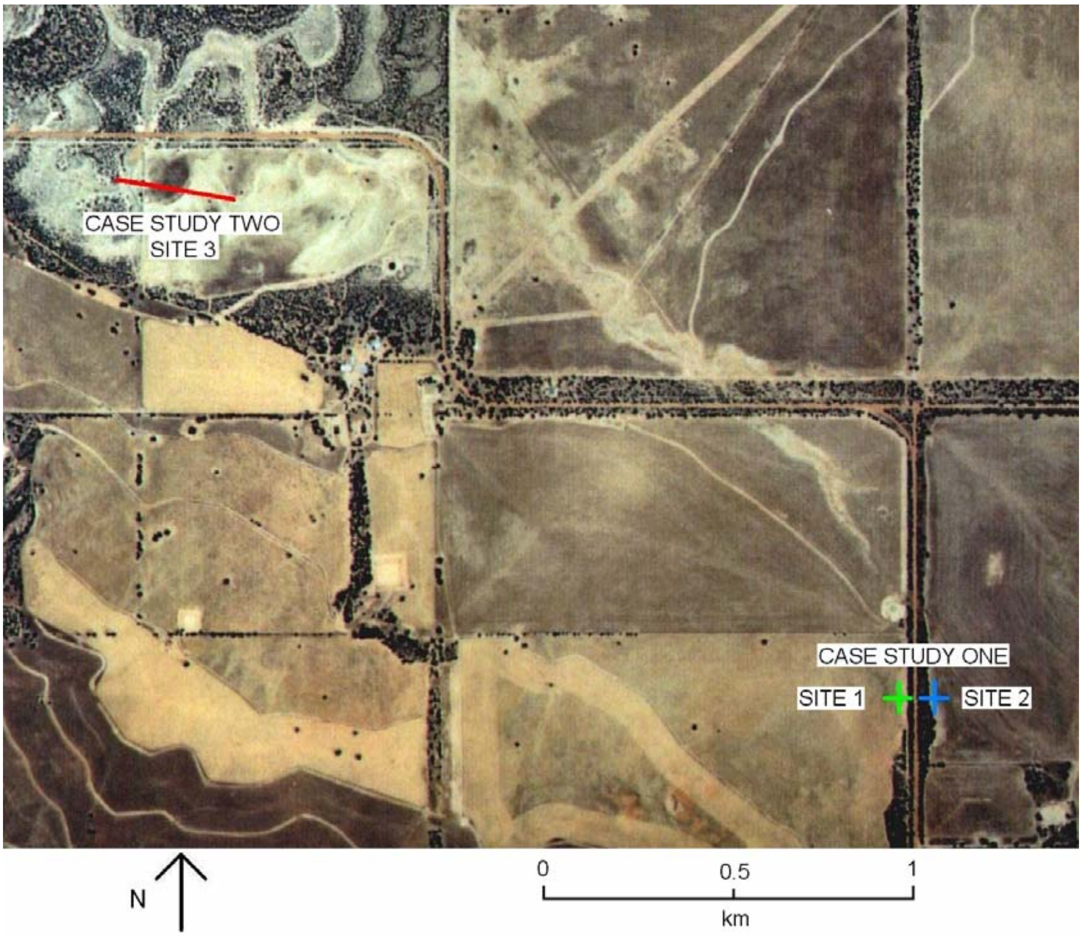


Figure 2 1994 DOLA aerial photograph showing study sites

The writers were advised that the barley would be lush and above the knees in an average year. The main difference between the two sites was the management regimes. Site 1 was prepared with the biodynamic preparation 500 once per year and competitive weeds were removed using cultivation techniques. Although no Biodynamic preparation was used in 2002 due to the drought conditions. Site 2 used conventional chemical fertilisers like Agras, Urea, Superphosphate along with herbicides like Roundup Max, MCPA, Tigerex, Gramoxone (for pastures) etc.

2 HISTORY OF LAND USE

Year Units	Site1 (BD)	Site2 (CV)	Rainfall (mm)
2002	barley	barley	146*
2001	pasture	wheat	374
2000	pasture	pasture	382
1999	pasture	wheat	521
1998	wheat	pasture	377

Table 1 The history of land use and rainfall over the previous five years. * Total rainfall for 2002 was taken up to the end of September.

3 METHODOLOGY

The project was carried out using standardized physical, chemical, and biological field procedures in order to provide a measured basis for comparison and indicative interpretation of the two study sites chosen.

The United States Department of Agriculture have a "Soil Quality Test Kit Guide" for performing field tests, and it was this guide along with other field procedures gathered that was used in this study.

The tests carried out include:

3.1 Physical: Soil Classing, Temperature, Penetrometer, Vane Shear, Bulk Density, Soil Porosity, Soil Water, Infiltration, Slaking, Aggregate Stability (Organic Matter).

3.2 Chemical: Salinity (EC), Sodicity, Calcium, pH, Nitrogen.

3.3 Biological: Respiration.

4 RESULTS AND DISCUSSIONS

4.1 Description of soil types

The soil type on the farms was generally considered sand over clay, where the depth of the hard clay pan generally varies from around 30 cm to 1 metre deep.

The top sand layer varies slightly but can be considered to be a Clayey Sand (~10% clay). The topsoil in the region could be classed as a 'Brown deep sand'. The bedrock or parent material is generally situated about 3 to 4 metres down and can be considered a local groundwater flow system, which gives reason why there are such extensive water logging problems especially with collapsed soil.

4.2 Compaction

The surface compaction in the top 50mm was measured with a Shear Vane. A shear vane is an elongated cross of metal on a vertical shaft which is forced at right angles into the top 50mm of soil and then twisted. The maximum resisting torque is measured on a torque dial and recorded. A simple but effective, reproducible measure commonly used in geomechanics. Typical values for the dry condition for site 1 (BD) and site 2 (CV) were 34 and 54.4 Newton-metres.
The bulk density for the wet condition for site 1 (BD) and site 2 (CV) was 1.39 and 1.48 gram per centimetre cubed whereas the corresponding soil porosity was 47.6 and 44.0 percent respectively. The above illustrates that the top 50 mm was less compacted on the biodynamically managed soils.

The soil profile compaction was measured with a pentrometer. The pentrometer is a standard instrument used in geomechanics for the testing of the compaction of road pavements. The test comprises the driving of a vertical steel bar into a foundation material using a series of standard vertical blows to the vertical bar.
The test is simple, reproducible and effective in measuring compaction. Typical pentrometer results for both the wet and dry conditions are shown in figures 3 and 4.

For both conditions (wet and dry) the conventionally farmed soil required more blows to penetrate the soil profile and the deeper the steel shaft went, the harder the conventional soil profile was to penetrate.
It is of interest to note that for the wet conditions about one third less energy was needed.

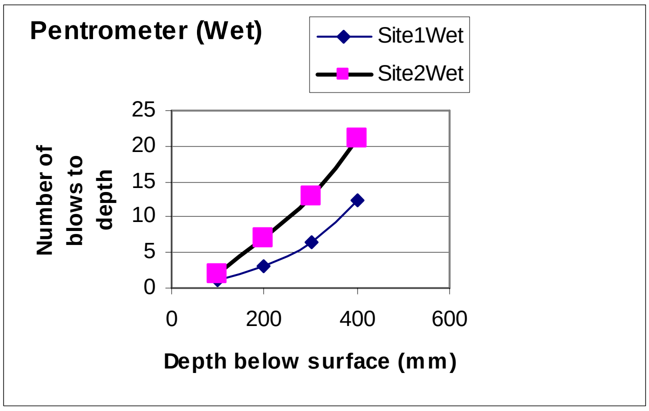


Figure 3 showing pentrometer readings for the wet condition.

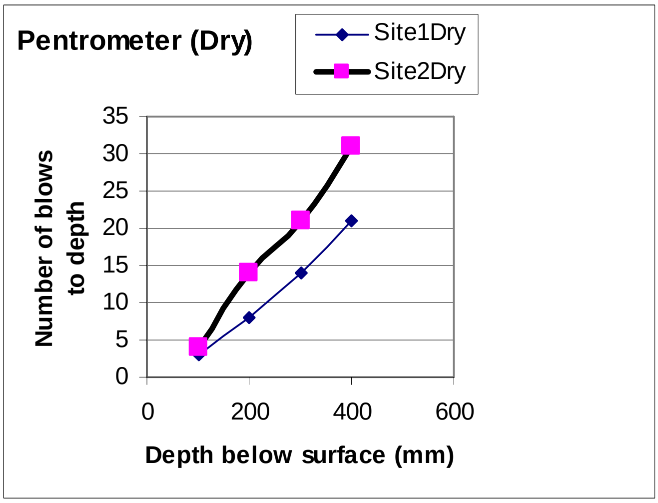


Figure 4 showing the pentrometer readings for the dry condition.

The above field test illustrated that the conventionally managed soil in both the 50 mm top layer and the soil profile to a least a depth of 400 mm depth was more compacted with less porosity than the biodynamically managed soils.

4.3 Infiltration

Infiltration test were also conducted at both sites to determine how freely water would pass through a wet or dry soil profile. This was done by driving a 100mm diameter steel ring 50mm into the top soil and filling the exposed cup with water to a height of about 100 mm. After ten minutes the ring would be topped-up with a measured volume of water and the infiltration assessed. Figure 5 shows the typical infiltration of water over 10 minutes periods for the undisturbed dry sites. Steady state infiltration conditions were experienced after 40 minutes.

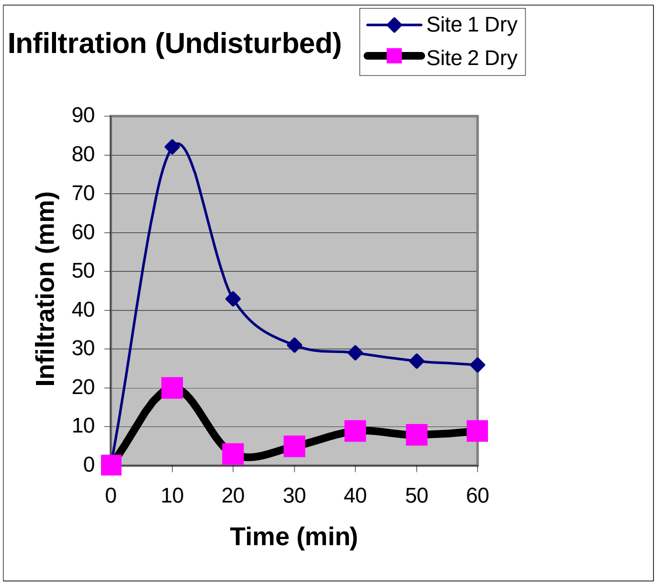


Figure 5 showing the infiltration readings for the dry, undisturbed condition.

From figure 5 it can be seen that for the first 10 minutes the infiltration of the biodynamically managed soil was about four times that of the conventionally managed soil with a steady state infiltration being about two and a half times higher.

The above test offers an indirect measure of the structure of the soil in the soil profile. Clearly the movement of water into the biodynamically managed soils was less impeded to that of the conventionally management soils and that high rainfall intensities on conventionally managed soils could not be immediately absorbed. These results confirmed John Cashmore's observations that no longer did overland flow of water occur on his property and that the existing Worthington banks were no longer needed to contain overland flow. The average yearly rainfall, from 1987 to 2001 at Hyden was 401mm (15.8 inches) per year, however, at times it is characterised by intense rainfall. A key finding was when an infiltration test had been conducted on a disturbed area, such as where the experimenters had been walking, it was found that the infiltration rates on the biodynamically managed soils were reduced by about a half. Thus, indicating the very delicate nature of the sandy soils and their response to compaction.

4.4 Moisture content and organic carbon content in the soil

The water holding capacity, for the wet condition, in the top 50mm of soil at site 1 (BD) and site 2 (CV) was 38.7% and 21.2% respectively, whereas, the organic carbon content was 0.13% and 0.06%, indicating the biodynamically managed soils were holding about twice the amount of soil moisture and contained about double the soil organic carbon. This supports John Cashmore's observations that his crops always remain greener for two to three weeks longer than those of neighbours in the district. The very low levels of organic carbon for both sites does not account for double the soil moisture in the soil at site 1 and it is thought the soil structure entraps the additional water.

4.4 Aggregate Stability

The appearance of aggregates coincides with many soil constituents relating to organic matter, clay content and the chemistry of the soil. With an inrease in organic matter and an absence of exchangeable sodium (sodicity) in the soil, the soil on site 1 would have conditions favourable for creating water stable aggregates.

The tests confirmed what was seen on the surface of the biodynamically managed soil: there were numerous aggregates to be seen on the surface and the surface was soft under foot. This contrasted starkly with the surface of site 2 which had very few aggregates and what was there were very hard and not soft under foot.

It should be noted that aggregates are important for the movement and storage of soil water along general soil structure. These findings support John Cashmore's observation that "Nyonger" does not 'blow' when it is being worked. John also said that he did not need large horse-powered tractors and that he travelled at half the speed to protect his delicate soil.

4.6 Soil Chemistry

Site 1 (BD) and site 2 (CV) both recorded low salinity readings. Values in table 2 and 3 are very low compared to the salt scald areas studied in case study two. It is of interest to note that site 1 (BD) was found to be non-sodic whereas site 2 (CV) was medium sodic which could be attributed to the lower levels of calcium carbonate ($CaCO_3$) measured in the soil. The Calcium ion replaces the Sodium ion and stabilises the clay particles and prevents them from dispersing. This in turn could lead to blocked pore spaces, potentially creating an almost impermeable layer for water movement through the soil profile.

Site1 (BD)	EC (dS/m)	EC (ppm)	pH (meter)	CaCo3	Sodicity
Dry	0.51	326	6.0	0.5	none
Wet	0.23	147	6.5		

Table 2 showing soil chemistry values for site 1(BD)

Site 2 (CV)	EC (dS/m)	EC (ppm)	pH (meter)	CaCo3	Sodicity
Dry	0.11	70	5.5	0.1	medium
Wet	0.10	64	5.9		

Table 3 showing soil chemistry values for site 2 (CV)

The pH of the biodynamically managed soil was found to be five time less acid than the conventional soil. Better germination of particular crops could be expected on the biodynamic soil because the soil is less acid.

4.7 Nitrates and Nitrites

Nitrifying and denitrifying soil bacteria play a critical role in supplying plant nitrogen in Australian agriculture. The presence of nitriates with depth, for the dry condition at site 1(BD) and site 2 (CV) is shown in table 4.

	Site 1 (BD)	Site 2 (CV)
Depth (mm)	Nitrate (ppm)	Nitrite (ppm)
0 – 50	150	25
At 200	10	0

Table 4 showing nitrate at depth for both sites for the dry condition.

4.8 Biological activity

The microbiology of soil is complex, however, the biological activity of a living soil can be readily established by measuring the respiration of the micro-organisms in the soil using the Solvita Kit. Table 5 compares the respiration of the micro-organisms for site 1 (BD) and 2 (CV) for both wet and dry conditions in the top 50 mm of soil.

	Site 1 (BD)	Site 2 (CV)
Dry	400	400
Wet	1125	750

Table 5 showing comparative respiration rates in Carbon Dioxide per kilogram per week. (CO_2/Kg/Wk)

It is to be noted that the respiration for both sites, for the drought conditions, was 400 (CO_2/kilogram/week) and that both increased with the wettings. The biodynamically managed soil displayed by far the highest respiration for the wet condition indicating a higher level of biological activity.

4.9 Temperature

The average temperature of the soil in the top 50 mm was 23.1^0C and 22.2^0C for site 1 (BD) and site 2 (CV) respectively, irrespective whether it was the wet or dry condition.

5 CONCLUSIONS

Case study one, which used standard field procedures, measured many attributes of the soil profile. These attributes confirmed John Cashmore's observations of the soil on "Nyonger' following 14 years of biodynamic best farming practice in the cereal wheat growing region of Western Australia: his soil was very delicate and required great care; his best farming management practice ensured it did not 'blow'; his crops remained greener for two to three weeks longer than his neighbours; in heavy rain 'Nyonger' no longer experienced overland flow and his soil was responsive to nature.

6 REFERENCES

Podolinsky, A. 2000 *Living Agriculture*, Published by the Bio-Dynamic Agricultural Association of Australia

7 ACKNOWLEDGEMENTS

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