# LONG TERM SOIL BIOLOGY TRIAL

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## AIM

To investigate the potential of biological and organic matter inputs to increase soil water storage, target long-term yield increases and soil improvement.

## BACKGROUND

This trial forms part of the Liebe Group's GRDC funded soil health project **'A sustainable dryland community achieved through proactive research on effective management of the soil resource'.** This long-term trial has been established to address management of soil constraints limiting yield, specifically the biological component. The trial site was selected as it had no significant chemical or physical soil constraints and is intended to demonstrate the capacity for increasing grain production through improving moisture conservation and enhancing the soil biota. The basic treatment structure of the trial was established in 2003 with a lupin crop and 2004 was the first cereal crop in which yields were obtained to reflect differences in treatment effects. Wheat (cv. Wyalkatchem) grown after brown manured lupins and wheat after addition of 20 t/ha organic matter (barley straw) were significantly higher yielding than the control, with a 500-600 kg/ha improvement or 18-22% increase in grain yield above the control treatments (harvested lupin: wheat rotation). In 2004, main treatment effects from a brown manure crop and addition of organic matter overshadowed any yield benefits from other treatments that aim to encourage microbial activity. However, this was not unexpected as improving soil biological fertility is a long-term process. In 2005, the trial was again sown to wheat (cv. Wyalkatchem) to assess residual value of treatments and to determine the ongoing improvement to the soil resource. Results from 2005 are presented below.

## TRIAL DETAILS

| | |
|---|---|
| **Property** | Liebe Long Term Research Site (LTRS), West Buntine |
| **Plot size & replication** | 10.5m x 80m x 3 replicates |
| **Soil type** | Yellow sand |
| **Sowing date** | 4th June 2005 |
| **Seeding rate** | 80 kg/ha Wyalkatchem |
| **Fertiliser (kg/ha)** | 100 kg/ha MAPSZC, 60 L/ha UAN |
| **Paddock rotation** | 2004 Wheat, 2003 Lupin, 2002 Wheat |
| **Herbicides** | 1.0 L/ha Roundup + Hammer, 2.0 L/ha SpraySeed, 2.0 L/ha Stomp, 500 mL/ha MCPA LVE + 3 g/ha Ally |
| **Growing Season Rainfall** | 270.4mm (April-October) |

### Trial Design

The trial consists of 17 treatments replicated 3 times. The site was deep ripped to 300mm on 450mm spacing prior to seeding in 2004, to ensure subsurface compaction was not constraining yield. Average topsoil pH across all treatments in 2005 is 5.26 (Table 4).

### Treatments 2005 –

1. Control (full stubble retention)
2. Control (full stubble retention)+ Humates
3. Control (full stubble retention)+ Zeolite
4. Control (full stubble retention)+ Microbes (foliar application)
5. Control (full stubble retention)+ Humates + Zeolite + Microbes (foliar application)
6. Brown manure Lupin 2003 (full stubble retention of 2004 cereal crop)
7. Brown manure Lupin 2003 (full stubble retention of 2004 cereal crop) + Humates
8. Brown manure Lupin2003 (full stubble retention of 2004 cereal crop) + Zeolite

9. Brown manure Lupin2003 (full stubble retention of 2004 cereal crop) + Microbes
10. Brown manure Lupin 2003 (full stubble retention of 2004 cereal crop) + Humates + Zeolite + Microbes
11. Tilled soil (incorporate all stubbles)
12. Tilled soil (incorporate all stubbles) + decomposing agent
13. Tilled soil (incorporate all stubbles) + Load up organic matter (2003 only)
14. Tilled soil (incorporate all stubbles) + Load up organic matter (2003 only) + decomposing agent
16. Burnt stubble (Brown manure Lupin 2003, burn 2004 cereal stubble)
17. Western Mineral Fertiliser Package

**Table 1**. Rate and application method of various treatment components.

| Treatment | Rate | Application Method |
|---|---|---|
| Organic matter (barley straw 2004 only) | 20 t/ha | Spread pre seeding by hand |
| Brown manure Lupin (2003 only) | 5 t/ha biomass | Foliar Desiccant |
| Zeolite | 1 t/ha | Top dressed pre seeding |
| Humates | 5 kg/ha | Top dressed pre seeding |
| Decomposing agent | 10 L/ha brewed concentrate | Pre seeding spray |
| Microbes | 20 L/ha brewed concentrate | Post emergent foliar spray |
| Western Mineral Package | | |
| Dolomite (2004 only) | 650 kg/ha | Top dressed pre seeding |
| WMF NPK Crop mineral fertiliser (microbe coated) | 120 kg/ha | Banded below seed |
| Liquid UAN | 60 L/ha | Banded below seed |
| WMF Ag Blend microbes plus Liquid activator | 150g microbe+150mL activator /ha | Post emergent foliar spray |

## Results

Table 2**. Yield components of Wyalkatchem wheat obtained from various treatments in 2005**

| **Treatment** | **Yield (t/ha)** | **Biomass at anthesis (t/ha)** | **Plant density (no./m$^2$)** | **Head density (no.m$^2$)** | **Protein (%)** | **Screenings (%)** | **Gross Return ($/ha)*** |
|---|---|---|---|---|---|---|---|
| Burn Stubble | 2.79 a | 4.81 a | 115 | 303 ab | 9.00 abc | 1.73 | 346 |
| Till + OM + decomp agent | 2.60 ab | 5.06 a | 112 | 291 a-f | 9.30 a | 2.55 | 317 |
| Till + OM | 2.49 bc* | 4.63 a* | 112 | 286 a-g* | 9.06 ab | 1.95 | 309 |
| BM + humate | 2.44bcd | 3.36 b | 118 | 293 a-e | 8.67 def | 2.04 | 293 |
| Control+hum+zeo+mic | 2.38 bcde | 3.92 b | 115 | 299 abcd | 8.60 defg | 1.41 | 290 |
| BM + zeolite | 2.34 bcde | 4.24 a | 120 | 301 abc | 8.83 abcd | 2.26 | 281 |
| BM +microbe | 2.33 bcde | 4.11 a | 122 | 265 a-h | 8.43 fgh | 1.78 | 280 |
| WMF package | 2.31 bcde | 4.07 ab | 110 | 252 efgh | 8.70 bcde | 1.83 | 282 |
| BM + hum + zeo + mic | 2.30 bcde | 4.21 a | 112 | 304 a | 8.35 fghi | 1.49 | 276 |
| Brown manure | 2.25 cde | 4.33 a | 108 | 268 a-h | 8.00 ij | 1.74 | 270 |
| **Control** | **2.23 cde** | **3.58 b** | **117** | **270 a-h** | **8.00 ij** | **2.02** | 263 |
| Control + zeolite | 2.18 de | 3.66 b | 113 | 236 h | 8.10 hij | 1.73 | 262 |
| Till | 2.17 de* | 4.09 b* | 117 | 273 a-h* | 8.07 hij | 2.25 | 256 |
| Till + decomposing agent | 2.11 de | 4.18 a | 112 | 272 a-h | 7.97 j | 1.99 | 247 |
| Control + humate | 2.08 e | 3.55 b | 112 | 276 a-h | 8.15 hij | 1.65 | 250 |
| Control + microbe | 2.08 e | 3.80 b | 110 | 260 a-h | 8.20 hij | 2.37 | 245 |
| LSD (5%) | 0.33, 0.29* | 1.05, 0.91* | - | 45.2, 39.2* | 0.38 | n.s. | - |

* Gross returns calculated on EPR for APW matrix of $191/t FOB for week starting 1st December 2005

The long-term biology trial provided some very interesting results in 2005. The yields obtained reflect what many farmers encounter in the initial phases of converting to a full stubble retention system as opposed to stubble burning and these yield differences relate mostly to a change in the C:N balance and microbiological processes that occur in the soil. Wheat grain yields achieved between 78% and 105% of their water limited yield potential (2.76 t/ha based on 30% of Jan-Apr rainfall & 70% May rainfall + June-Oct rainfall minus evaporation of 110mm for June sown crop).

The highest yielding treatment was burnt stubble, yielding 560 kg/ha or 25% greater than full stubble retention (control).

A proportion of this yield improvement may be attributed to a combination of an increase in short term availability of nitrogen due to burning a high C:N ratio material (wheat straw) and also an initial decrease in nitrogen availability and immobilisation in the stubble retained treatment. Benefits may also be associated with a reduced weed burden under burnt stubble treatments. Whilst it is difficult to illustrate changes in soil nitrogen reserves as the season progresses without an expensive and intense sampling procedure, the results of topsoil analysis (Table 4) sampled at approximately 8 weeks after sowing (28$^{th}$ July 2005) suggest nominally higher soil nitrogen (as nitrate-N) in the stubble burnt treatment than in the full stubble retention (control) treatment. However, this does not account fully for the differences in yield observed in this trial.

**Table 4.** Topsoil analysis of treatments as sampled at 28$^{th}$ July 2005.

| | Nitrate N (mg/kg) | Ammonium N (mg/kg) | Phosphorous (mg/kg) | Potassium (mg/kg) | Sulphur (mg/kg) | Organic Carbon (%) | Iron (mg/kg) | pH ($CaCl_2$) |
|---|---|---|---|---|---|---|---|---|
| **Control** | **6** | **2** | **27** | **37** | **4.0** | **0.58** | **289** | **5.17** |
| Control+Humate (H) | 8 | 1 | 26 | 35 | 5.5 | 0.59 | 409 | 5.20 |
| Control+Zeolite (Z) | 6 | 1 | 26 | 32 | 4.1 | 0.51 | 328 | 5.27 |
| Control+Microbe (M) | 8 | 1 | 22 | 27 | 4.1 | 0.67 | 304 | 5.17 |
| Cont+H+Z+M | 6 | 1 | 26 | 35 | 4.2 | 0.57 | 310 | 5.33 |
| BrownManure (BM) | 8 | 2 | 27 | 44 | 4.2 | 0.55 | 326 | 5.17 |
| BM+humate | 5 | 1 | 21 | 29 | 3.7 | 0.60 | 325 | 5.27 |
| BM+Zeolite | 8 | 1 | 27 | 41 | 5.5 | 0.63 | 332 | 5.33 |
| BM+Microbes | 7 | 2 | 24 | 39 | 4.4 | 0.57 | 328 | 5.30 |
| BM+H+Z+M | 7 | 1 | 28 | 31 | 4.5 | 0.58 | 298 | 5.30 |
| Till+OrganicMatter (OM) | 8 | 2 | 31 | 61 | 4.5 | 0.66 | 290 | 5.27 |
| Till | 6 | 1 | 25 | 40 | 3.2 | 0.61 | 316 | 5.30 |
| Till+OM+decomposing agent | 8 | 2 | 29 | 85 | 3.3 | 0.54 | 320 | 5.30 |
| Till+decomp agent | 7 | 1 | 24 | 39 | 3.9 | 0.61 | 330 | 5.20 |
| Burnt | 9 | 1 | 29 | 51 | 4.2 | 0.71 | 317 | 5.23 |
| WMF | 9 | 1 | 26 | 51 | 4.3 | 0.60 | 338 | 5.40 |
| LSD 5% | n.s. | n.s | 6 | 21 | 1.6 | 0.15 | 80 | n.s. |
| CV% | 33 | 35 | 15 | 30 | 23 | 15 | 15 | 3 |

Stubble management also has other nutrient implications. The nutrient values of stubbles can vary depending on crop type, fertiliser history and growing season conditions. The two treatments that received an addition of organic matter (barley straw) in 2003 show a much higher level of potassium in the topsoil than compared to all other treatments. This illustrates one of the long-term benefits that can be achieved in the coming years under a stubble retention system.

In 2004, a yield benefit of 600 kg/ha (22%) was obtained in wheat grown after brown-manured lupins (2003) compared to wheat after a harvested lupin crop. In 2005, a 20% increase in plant biomass measured at anthesis reflects a similar response to brown manure treatments, but was not reflected in the grain yield. Therefore conditions in 2005, appear to have set up the wheat crop early but not been able to sustain those differences during grain filling. Thus in 2005, there was no further yield benefit observed suggesting the influence of a brown manure lupin crop on sandplain may be relatively short-lived depending on seasonal conditions. This is also reflected in similar soil nitrogen concentrations in brown manure lupin treatments compared to retention of standing lupin stubble under the second cereal crop in 2005.

One of the main aims of this trial is to demonstrate the yield improvements that can be obtained from improving soil condition, including the importance of biological aspects of soil health. Although too early to yet fully understand, the lower yields obtained in the initial phases of converting to full stubble retention systems may be associated with initial microbial immobilisation of nitrogen associated with stubble decomposition. Where this occurs, this yield penalty could be minimised if as much stubble as possible is allowed to decompose prior to seeding successive crops. In order to maximise stubble decomposition optimum conditions of close stubble-soil contact, adequate nitrogen, moisture, temperature and oxygen are required. However, in this trial it does not appear as though nitrogen immobilisation due to incorporation of organic matter is a significant impediment to grain production as the grain yield of the two treatments that include large additions of organic matter to soil returned yields greater than the control treatment. This is further demonstrated in incorporated (tilled) treatments, where the level of stubble-soil contact was increased (to increase decomposition rates of organic material) yet yielded similarly to minimum-tillage treatments. Higher grain protein in treatments which yielded well (and included organic matter treatments) also suggests this is not the main driver of grain yield changes. This trial was only established 2 years ago and thus in terms of long term yield improvement, it may be several years before major changes under stubble retained treatments are observed compared to treatments where stubble has been burnt each year.

The pros and cons of stubble retention and stubble burning are well known by most. Burning stubble, in its various forms, can be a useful strategic management tool in the system to improve weed and disease control. In this trial, a complete burn of standing stubble just prior to seeding was used. Although the level of infection for yellow leaf spot (low) and Septoria Nodorum (low) was not noticeably different between treatments, it is possible that some yield improvement in the burnt stubble treatments could also be attributed to lower disease infection. The presence of higher weed burdens in unburnt treatments may also be a consideration. Longer term (17 year) burning of stubble has also been demonstrated to reduce microbial biomass and activity, and is therefore considered important in the biological supply of nutrients, which in turn influences grain yield.

Research and trial work across Australia has shown that stubble retention does eventually lead to an improved soil resource.

Some of these benefits include an increase in soil water and plant available water, increases in soil organic carbon, a decrease in soil erosion, decrease in soil bulk densities, improved biological fertility and a generally improved soil structure. Whilst it is too early to pick up these changes in soil properties between stubble retained and burnt treatments so early in the life of this trial, the addition of organic matter and incorporation of residue in current farming systems, provides an insight of what to expect a few years down the track. Within this trial, the treatment whereby 20 t/ha of barley straw was added to the plots and incorporated by offset discs, illustrates what an addition of organic matter to the system can achieve and potentially what could be achieved after several years of stubble retention. A trend towards greater soil moisture in the top 10cm of the profile was found at seeding time for the till plus organic matter treatment over the control plots (Figure 3). This may be important for the early establishment and increased vigor of seedling growth. Soil moisture below 10cm at time of seeding and for the entire profile at harvest did not appear to significantly differ between treatments (Figure 1, Figure 2).

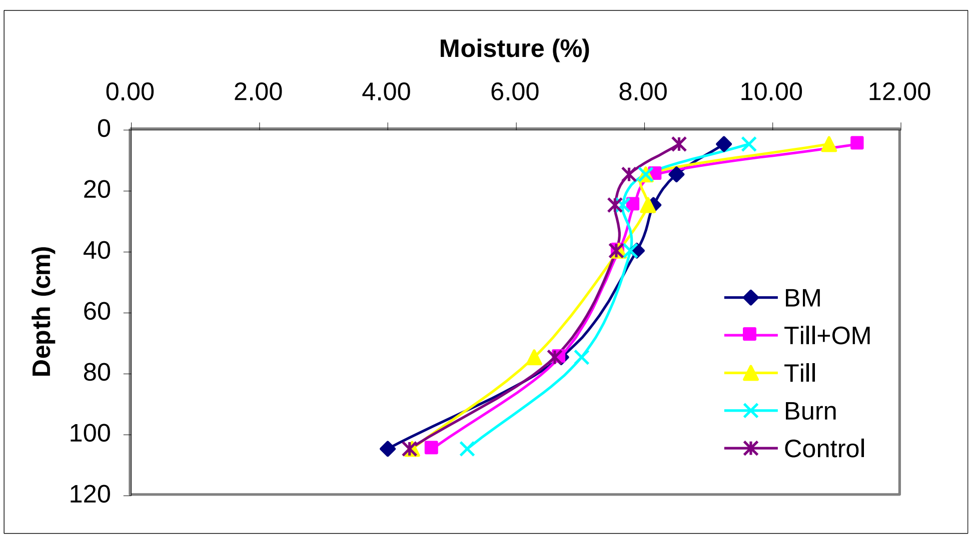


**Figure 1**. Gravimetric soil moisture (%) of selected treatments at five soil depths (0-10, 10-20, 20-30, 30-60, 60-90cm) during wheat harvest November 2005.

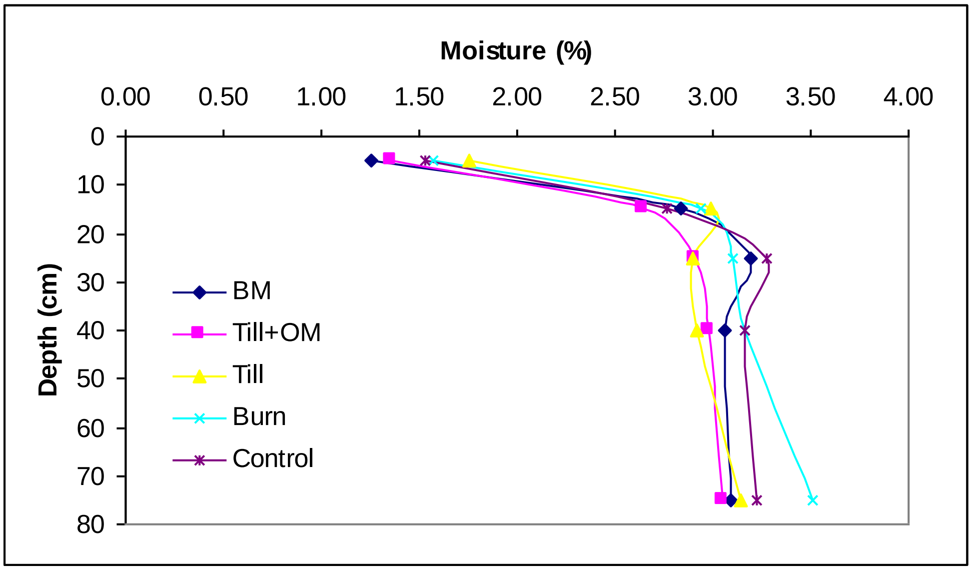


**Figure 2**. Gravimetric soil moisture (%) at six depths (0-10, 10-20, 20-30, 30-60, 60-90, 90-120cm) under selected treatments at time of sowing (June 2005).

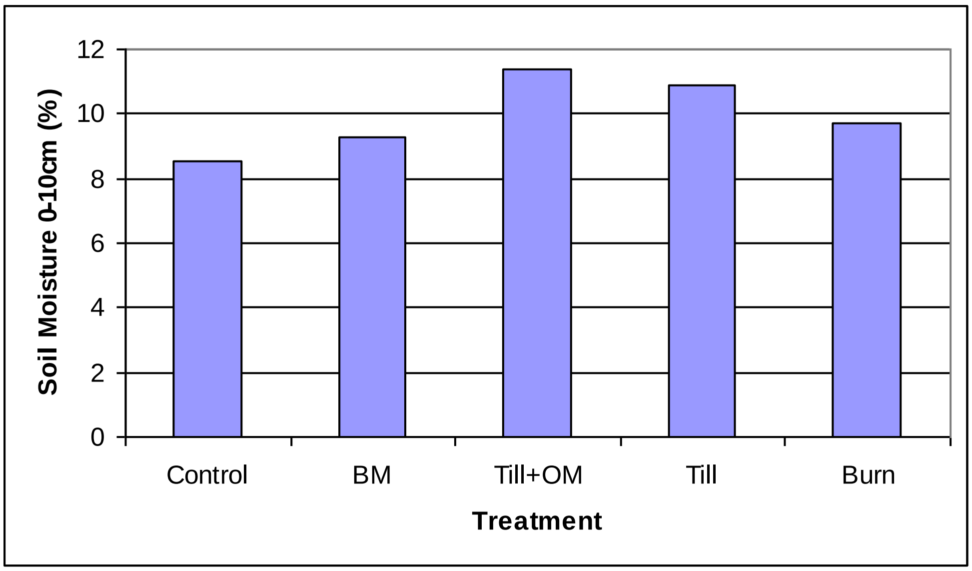


**Figure 3.** Gravimetric soil moisture content at 0-10 cm at time of sowing June 2005 (LSD = 2.58).

Bulk densities of all treatment plots were collected in 2005 and although there were are no consistent trends between treatments it does appear that the treatments receiving a large input of organic matter do have lower densities than other treatments (Table 3). Soil resistance indicates that the effect of deep ripping conducted in 2003 prior to the implementation of this trial has been short-lived with indications of a hard pan developing at 30cm (where previously this had been removed during 2004. Thus root penetration to deeper soil layers (and associated water and nutrients) may have been constrained. Soil resistance, when measured with a penetrometer is best collected when the soil profile is at its upper drained limit. Due to the dry July/August period experienced in 2005, penetrometer data was not able to be collected at the optimum time, thus recorded values of soil resistance may be higher than actual resistance as present in the field. Soil biology data has been collected and once processed will be included in subsequent newsletters.

This trial was designed to improve long term yield increases through improved water storage and soil biology. As such, it will continue into the future with the ongoing collection of valuable data to assist in the evaluation of the treatments being trialed.

**Table 3.** Bulk density (0-10cm) of treatments sampled prior to sowing for the long term soil biology trial.

| **Treatment** | **Bulk** |
|---|---|

| | Density ($g/m^3$) |
|---|---|
| Brown Manure + Zeolite | 1.45 |
| Control + Zeolite | 1.43 |
| Control + Humate + Zeolite + Microbe | 1.43 |
| **Control** | **1.41** |
| Burn | 1.40 |
| Brown Manure + Humate | 1.40 |
| Brown Manure + Humate + Zeolite + Microbe | 1.40 |
| Brown Manure + Microbe | 1.40 |
| Till + decomposing agent | 1.40 |
| Control + Humate | 1.40 |
| Till | 1.38 |
| Control + Microbe | 1.38 |
| Western Minerals Fertiliser | 1.36 |
| Till + Organic Matter | 1.36 |
| Brown Manure | 1.33 |
| Till + Organic Matter + decomposing agent | 1.32 |
| LSD 5% | 0.08 |

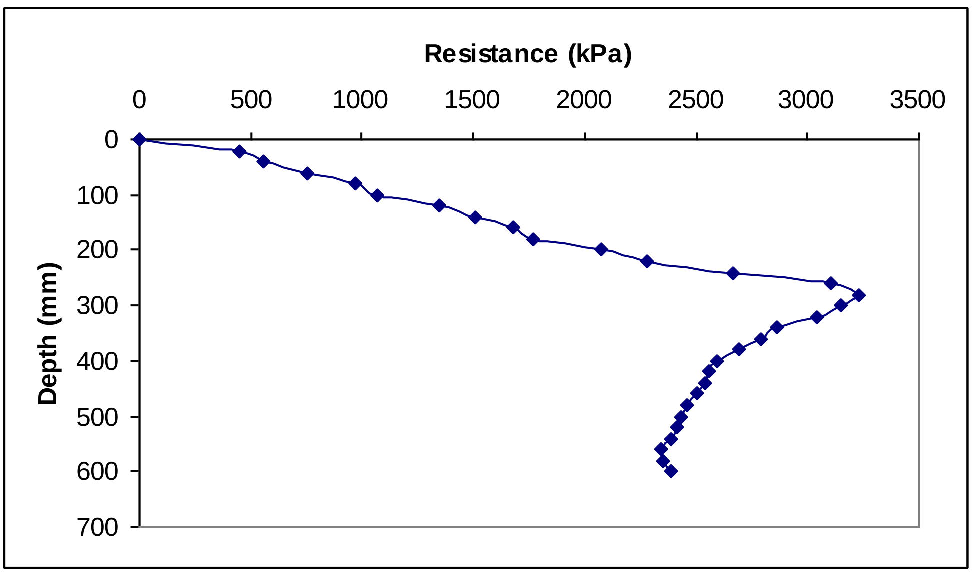


**Figure 4**. Soil resistance of control plot to 600mm in August 2005.

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