LONG TERM SOIL BIOLOGY TRIAL

Lara Swift, Project Coordinator, Liebe Group

AIM

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

BACKGROUND

This trial forms part of the Liebe Group's GRDC funded adoption project, **'Growers critically analysing new technologies for improved farming systems'** and continues work of the previous 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 to increase grain production through improved moisture conservation and optimized soil biological functioning. The basic treatment structure of the trial is one year in lupins followed by two years of wheat. Yields were obtained to reflect differences in treatment effects in the wheat rotations.

In 2004 wheat (cv. Wyalkatchem) grown after brown manured lupins, and wheat after the addition of 20 t/ha organic matter (barley straw) yielded 500-600 kg/ha (18-22%) more grain than control treatments (harvested lupins). Any additional treatments that aimed to increase yield through encouraging microbial activity failed to improve grain yield in comparison to the control (e.g. zeolite and humate).

In 2005 the trial was again sown to wheat (cv. Wyalkatchem) to assess the residual value of treatments and determine ongoing changes to the soil resource. In 2005, the long term biology trial provided interesting results with burnt stubble plots yielding 560 kg/ha or 25% greater than full stubble retention (control). This reflects what many farmers encounter in the initial phases of converting to a full stubble retention system as opposed to stubble burning and relates mostly to a change in C:N balance and soil microbiological processes.

In 2006 lupins were used in rotation for weed control and provide a break crop for cereal disease. As the trial was in the lupin phase of the rotation some plots received 20 t/ha of canola chaff, while others were brown manured. Harvest cuts were not obtained in this year hence yield results and gross margins have not been presented in the report.

In 2007 the trial was sown to wheat (cv. Wyalkatchem). The aim was to assess the combined effect of the residual and new organic matter and brown manure treatments together with the continued annual treatments on the soil resource. However, a significant weed burden was observed during the season and attempts to control the weeds post emergent herbicides were unsuccessful. A broad spectrum knock down (2 L/ha Sprayseed®) was used late in the season to reduce weed burden for the following season. Although grain harvest in 2007 was prevented, additional biomass was removed from the site using normal harvesting management.

In 2008 the trial was again sown to wheat (cv. Wyalkatchem) to evaluate ongoing changes to the soil health and to investigate any residual effects being experienced from past treatments. The highest yielding treatment was tilled soil with organic matter, yielding 23% more than full stubble retention (control). For more information and results please see below.

TRIAL DETAILS

Property	Liebe Group Long Term Research Site, West Buntine
Plot size & replication	10.5m x 80m x 3 replicates
Soil type	Yellow sand
Sowing date	27/5/08-28/5/08
Seeding rate	70 kg/ha Wyalkatchem wheat
Fertiliser	27/5/08-28/5/08: 95 kg/ha Gusto, 125 L/ha UAN
Paddock rotation	2002 = Wheat, 2003 = Lupins, 2004 = Wheat, 2005 = Wheat, 2006 = Lupins, 2007 = Wheat
Herbicides	27/5/08: 1.25 L/ha Sprayseed, 2.5 L/ha Boxer Gold 22/7/08: 330 mL/ha Atlantis 15/8/08: 60 g/ha Lontrel, 300 mL/ha LVE MCPA
Growing Season Rainfall	330mm

TRIAL DESIGN

The trial consists of three banks of 19 randomised plots. The average topsoil pH across all treatments in 2008 is 6.34.

Treatments 2008:

1. Control (full stubble retention)
2. Control (full stubble retention) + Custom Compost
3. Control (full stubble retention) + Humate
4. Control (full stubble retention) + Microbes
5. Control (full stubble retention) + Custom Compost + Humate + Microbes
6. Brown manure lupin 2006 (full stubble retention of 2007 cereal crop)
7. Brown manure lupin 2006 (full stubble retention of 2007 cereal crop) + Custom Compost
8. Brown manure lupin 2006 (full stubble retention of 2007 cereal crop) + Humate
9. Brown manure lupin 2006 (full stubble retention of 2007 cereal crop) + Microbes
10. Brown manure lupin 2006 (full stubble retention of 2007 cereal crop) + Custom Compost + Humate + Microbes
11. Burnt stubble
12. Tilled soil (incorporate all stubbles)
13. Tilled soil (incorporate all stubbles) + Decomposing agent
14. Tilled soil (incorporate all stubbles) + Organic matter (barley straw 2004, canola chaff 2006)
15. Tilled soil (incorporate all stubbles) + Organic matter (barley straw 2004, canola chaff 2006) + Decomposing agent

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

Treatment	Rate	Application method
Brown manure (BM) lupins phase (2003 & 2006 only)	5 t/ha biomass (2003) 1.3 t/ha biomass (2006)	Foliar desiccant (1 L/ha Glyphosate)
Custom Compost (CC)	50 kg/ha (50% mix with conventional fertiliser)	Down the tube at seeding
Decomposing agent (DA)	10 L/ha brewed concentrate	Pre seeding spray
Humate	5 kg/ha	Top dressed pre seeding
Microbes	20 L/ha brewed concentrate	Post emergent folia spray
Organic matter (OM) (barley straw 2004, canola chaff 2006)	20 t/ha	Spread pre seeding by hand

RESULTS

Table 2: Grain yield components of Wyalkatchem wheat grown in 2008 under treatments imposed at the Liebe long term trial site.

Treatment Averages	Yield (t/ha)	Harvest Index (%)	Biomass at anthesis (t/ha)	Hect. weight (g)	Prot. (%)	Screen. (%)	Plant density (no./m²)	Head density (no/m²)	Grain density (no/head)
1. Control	**2.64**	**56.4**	**3.2**	**80.6**	**10**	**1.12**	**24**	**107**	**38**
2. Control + CC	2.43	57.1	2.7	81.4	10.6	1.37	18	101	39
3. Control + Humate	2.74	54.1	3.6	80.1	10.1	1.20	16	99	43
4. Control + Microbes	2.44	56.2	2.9	80.1	10.6	1.22	17	98	36.3
5. Control + CC + Humate + Microbes	2.59	56.8	2.3	80.7	10.5	1.25	18	88	38
6. BM control	2.73	61.6	3.3	80.7	10.7	1.20	17	106	39.5
7. BM + CC	2.49	55.4	2.3	80.7	10.5	1.25	21	107	39.7
8. BM + Humate	2.58	61.3	2.5	81.1	10.7	1.14	20	97	40
9. BM + Microbes	2.63	55.2	2.7	81.2	10.6	1.31	21	99	40.7
10. BM + CC + Humate + Microbes	2.94	59.9	3.0	80.8	10.2	1.13	18	94	44.7
11. Burnt stubble	2.89	58.9	3.6	80.8	10.2	0.96	19	92	37
12. Tilled soil	2.66	54.2	3.9	80.6	10.3	1.22	18	99	38
13. Tilled soil + DA	2.90	57.2	4.1	80.4	10.1	1.36	18	106	40.7
14. Tilled soil + OM	3.44	56.0	4.7	78.5	11.5	1.42	19	103	38.5
15. Tilled soil + OM + DA	3.20	59.1	4.6	77.6	12.4	1.65	10	135	35.3
LSD (5%)	0.609	8.64	2.25	7.80	1.69	0.659	5.1	21.5	10.25

The highest yielding treatment was tilled soil with organic matter, yielding 23% more than full stubble retention (control) (table 2). This could relate to microbial breakdown of additional organic matter, providing a significant source of nutrition throughout the growing season.

Interestingly, the tilled soil with organic matter and stubble decomposing agent treatment averaged the lowest plant density (plants/metre^2), whilst having the highest head density (heads/metre^2), suggesting the plant density allowed plants in those treatments to fully utilise light, moisture and nutrients.

Table 3: Soil analysis for 0-10cm as sampled in 2008.

	Nitrate N (mg/kg)	Amm. (mg/kg)	Phos. (mg/kg)	Potassium (mg/kg)	Sulphur (mg/kg)	Organic Carbon (%)	pH ($CaCl^2$)
1. Control	**7 ab**	**1**	**33 a**	**82 a**	**7.8 a**	**0.72 ab**	**5.45**
2. Control + CC	7 ab	1	35 a	95 a	5.6 a	0.85 bc	5.47
3. Control + Humate	6 ab	1	28 a	91 a	8.1 a	0.83 bc	5.57
4. Control + Microbes	5 a	1	36 a	74 a	9.5 a	0.80 abc	5.33
5. Control + CC + Humate + Microbes	7 ab	1	31 a	99 a	8.2 a	0.78 abc	5.57
6. BM control	9 ab	2	29 a	99 a	7.7 a	0.77 abc	5.42
7. BM + CC	11 b	1	30 a	80 a	7.4 a	0.75 ab	5.63
8. BM + Humate	9 ab	1	33 a	64 a	9.4 a	0.74 ab	5.30
9. BM + Microbes	9 ab	1	32 a	63 a	8.2 a	0.76 ab	5.40
10. BM + CC + Humate + Microbes	6 ab	1	34 a	68 a	8.8 a	0.87 bc	5.37
11. Burnt stubble	7 ab	1	31 a	69 a	6.7 a	0.63 a	5.17
12. Tilled soil	6 ab	1	30 a	66 a	8.6 a	0.73 ab	5.28
13. Tilled soil + DA	8 ab	2	30 a	79 a	8.5 a	0.80 abc	5.23
14. Tilled soil + OM	16 c	2	53 b	301 b	24.6 b	0.95 c	6.10
15. Tilled soil + OM + DA	19 c	2	53 b	299 b	20.9 b	1.00 c	6.40
LSD (5%)	5.9	1.39	9.4	54.5	5.71	0.184	11.183

Means followed by the same letter do not significantly differ.

One of the main aims of this trial is to demonstrate potential yield improvements to be obtained from improving soil condition, in particular the biological aspects of soil health. It is difficult to illustrate changes in soil

nitrogen reserves as the season progresses without expensive and intense sampling procedures. However, the results from the top-soil analysis (table 3) highlight a significantly higher soil nitrogen (measured as nitrate N) level in treatments where organic matter inputs have increased compared to both the stubble retained and cultivated soil control treatments and also show significantly higher phosphorus, potassium and sulphur levels in comparison to the control treatments. This was also reflective of previous treatments in 2003 where higher potassium concentrates were measured in organic matter treatments and illustrates one of the longer term benefits that can be achieved through stubble retention.

A significant increase in soil organic carbon was observed for both organic matter treatments (table 3) reflecting the addition of externally source canola chaff to these plots. Furthermore, the two organic matter treatments showed a much higher level of potassium in the top soil compared to all other treatments. This also illustrates the potential long-term benefits that can be achieved under a stubble retention system.

The addition of organic matter and incorporation of residue in current farming systems suggests continuing improvements in the soil resource. Although the addition of large amounts of organic residues, such as the 20 t/ha of canola chaff, it is unlikely to be a viable practices for the majority of broad acre growers, it clearly indicates the benefits of organic matter to the soil and perhaps what might be achieved after many years of stubble retention.

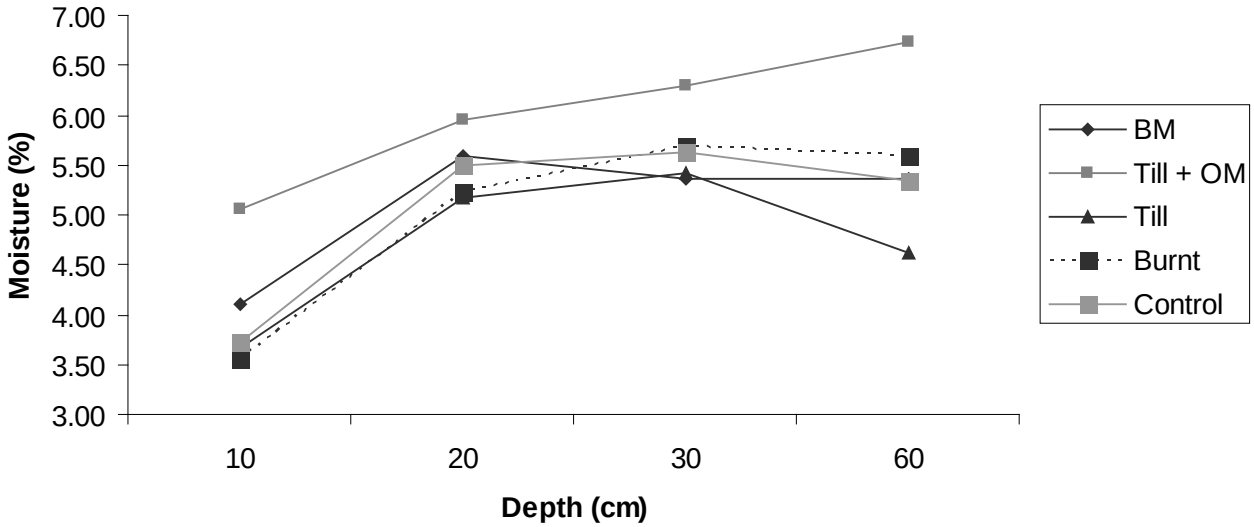

Figure 1: Gravimetric soil moisture (%) of selected treatments at four soil depths (0-10cm, 10-20cm, 20-30cm and 30-60cm) in 2008. Measurements were taken in May 2008.

The soil moisture results (figure 1) show a considerable improvement in moisture levels compared to the drier years in 2006 and 2007. Figure 1 indicates the addition of organic matter to the soil has improved moisture content at two times during the season. Long-term benefits of increased water holding capacity and organic matter content include improved soil structure and nutrient cycling.

Greater soil moisture in the top 10cm profile of the soil was evident in all treatments at seeding (figure 2). This top soil moisture plays a large role in the early establishment and increased vigor of seedling growth.

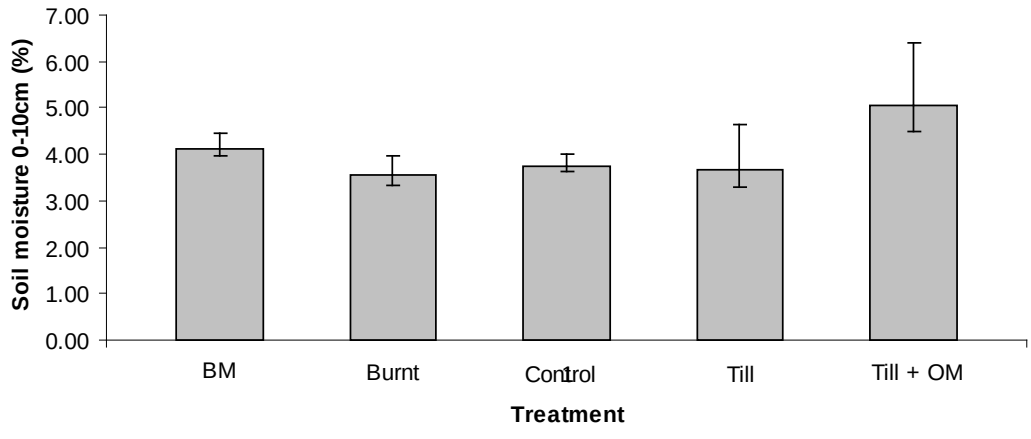

Figure 2: Gravimetric soil moisture content at 0-10cm in May 2008 showing means and ± standard error bars.

COMMENTS

- This trial was implemented in an effort to increase grain yield through improved soil water storage and soil biological functioning. Organic matter, whether as retained stubble or additional inputs, is a significant source of crop nutrition, and improved moisture conditions allow for optimal breakdown by soil microbes. The Liebe Group will continue to investigate long-term yield changes in response to these treatments with plans to seed the trial to lupins in 2009.

- Further investigation and trial work into the effect of chaff and straw from different crop species would have on yield and soil health properties would be interesting to evaluate.

ACKNOWLEDGEMENTS

- Liebe Group would like to express their appreciation to GRDC for assisting in the funding of this project and the assistance from Dan Murphy and Yoshi Sawada, The University of Western Australia and Fran Hoyle, Department of Agriculture and Food WA and Land and Water Australia.
- Thank you to Scholz Rural supplies, Syngenta, Summit Fertilizers, Wesfarmers Insurance and all other supporters of the long term research site for the generous sponsorship of products, advice and support throughout the year.
- Thanks also to Stuart McAlpine and staff, Mike Dodd and Rod Birch for conducting many of the paddock operations and Emma Wilson (formerly Liebe Group) for past input into the trial.

PAPER REVIEWED BY: ANDREW WHERRETT.

CONTACT:
Lara Swift
Email: lara@liebegroup.asn.au
Ph: (08) 9664 2030