FarmLink
Research Report 2014

05

The Soil Carbon Frontier

2014 Trial Site

Project Partners

FarmLink Research

Crop Facts Pty Ltd

Funding Partner

clean energy future

Australian Government
Department of Agriculture

GRDC
Grains Research & Development Corporation

Farmers leading and learning about the soil carbon frontier

Tony Pratt, Erika McAllister, FarmLink Research. Harm Van Rees, Cropfacts

Background

Work conducted by Clive Kirkby, CSIRO has investigated the feasibility of increasing soil Carbon (C) levels with the use of balanced amounts of nutrients and incorporation of stubble. His work has established that the humus (stable) portion of soil carbon has relatively constant ratio of C, Nitrogen (N), Phosphorus (P) & Sulphur (S).

Humus	Carbon	Nitrogen	Phosphorus	Sulphur
	1t	83kg	20kg	14kg

Indicating humus is an accumulation of carbon as well as other nutrients and that the creation of humus requires more than simply available carbon.

Other work conducted by various researchers found that soil carbon levels in Australia are low and a range of factors contribute to the soils ability to capture and store C including the parent material of the soil, rainfall and land use. The Federal government has provided funding to research agencies to test the impacts on soil C of a range of agricultural practices.

Introduction

This Federal Department of Agriculture project examined existing, new and alternative strategies for farmers in the wheat/sheep zone to increase soil carbon. The project has developed a network of trial and demonstration sites which are coordinated by key farming systems groups, one of which is FarmLink. NOTE: Not all data has been collected and analysed and so this is a report of progress and outcomes to date for the project.

Aim

The overall aim of the project was to raise awareness of farmers about how they can reduce green house gas emissions, sequester soil carbon and make improvements in farm productivity. Trials were established within this project to determine if –

- additional nutrients are required to increase the level of carbon stored in the soil and if this is impacted by the timing of the nutrient application AND/OR treatment of stubble residue; AND
- land use impacts soil carbon levels over time

These trials formed the basis of communication and extension activities designed to deliver trial outcomes and raise farmer awareness of soil carbon issues.

Methods

The project had two components, a fully randomized small plot trial and farmer scale replicated paddock trial.

Treatments applied in both the small and large scale trials to increase soil carbon included a range of stubble management practices with the addition of nutrients depending on the level of stubble present. Stubble load sampling was conducted post harvest, before treatments were applied, to match the required level of nutrient to stubble (C) present.

a. Small Plot Trial

The small plot trial was located at the Temora Agricultural Innovation Centre and examined the impact of different stubble treatments, nutrient rates and nutrient timings on soil carbon sequestration

The trial was established with a fully randomized 4 replicate design using the following treatments -

- Stubble treatments
  - Intact – standing stubble following harvest of the previous crop
  - Incorporated – stubble incorporated using an offset disc post harvest
  - Removed – stubble removed via mowing and raking of plots
- Nutrient treatments
  - Base – normal practice N and P
  - Extra – normal practice N and P, plus extra N, P & S
- Timing of Nutrient treatments
  - Nutrients applied at sowing
  - Nutrients applied at harvest of previous crop

The treatments are summarized in Table 1 and the trial design set out in Table 2.

												Replicates
8	5	6	3	12	11	4	7	9	10	1	2	4
1	7	2	4	8	5	12	9	10	11	3	6	3
7	4	3	6	11	9	1	5	8	2	12	10	2
9	10	8	1	2	4	12	11	6	7	3	5	1
12	11	10	9	8	7	6	5	4	3	2	1	Plot number

Table 2: Trial plan for small plot Trial, TAIC

Treatment	Stubble	Nutrients	Timing
1	Intact	Base	Sowing
2	Intact	Base	Harvest
3	Intact	Extra	Sowing
4	Intact	Extra	Harvest
5	Incorporated	Base	Sowing
6	Incorporated	Base	Harvest
7	Incorporated	Extra	Sowing
8	Incorporated	Extra	Harvest
9	Removed	Base	Sowing
10	Removed	Base	Harvest
11	Removed	Extra	Sowing
12	Removed	Extra	Harvest

Table 1: Treatment list for small plot trial, TAIC

The trials were repeated over 3 years and sown to crop in a wheat (2012), wheat (2013), canola (2014) rotation.

Stubble management for the small plot trial involved the removal of stubble residue, incorporation of stubble and stubble left intact. Removal of stubble was achieved by mowing and raking from the plots and incorporation was achieved by offset disc or Speedtiller – an example of which can be seen in Picture 1. Nutrients were spread by hand to ensure accurate plot distribution.

Standard soil and soil bulk density sampling was conducted in year 1 of the project and will be repeated in March 2015 to capture starting and end soil carbon and other nutrient levels.

The trial was assessed for stubble cover, crop establishment and grain yield in 2012, 2013 and 2014.

Picture 1: Small plot trial TAIC, post harvest incorporation and nutrient application. Incorporated plot on left, intact on right and reps of trial in background.

b. Paddock Scale Farmer Trials

The paddock scale trials were located on co-operator farms at Dirnaseer, Coolamon and Ariah Park in 2013 and 2014. The three treatments and trial plan are below (Tables 3, 4, 5 & 6). Sites were selected where cropping and pasture paddocks were adjacent – creating 'paired' paddocks. Initial soil testing was conducted on the paired paddocks in 2012 and will be conducted at the completion of the trial (March 2015) to compare start and finish soil composition under different management practices (ie cropping and grazing). Results from this experiment will be reported when available.

In addition to the paired paddock comparison, paddock scale trials, consistent with the small scale trial at TAIC, were implemented. The trials at Dirnaseer and Ariah Park were established with a fully randomized 4 replicate design while the trial at Coolamon contained three demonstration strips and these strips were discontinued in 2014. Three treatments were applied at each site as described in Table 3.

- Stubble treatments
  - Intact – standing stubble following harvest of the previous crop
  - Incorporated – stubble incorporated using a speed tiller
- Nutrient treatments
  - Base – normal practice N and P
  - Extra – normal practice N and P, plus extra N, P & S added pre-sowing

Treatment	Stubble	Nutrients
1	Intact	Base
2	Incorporated	Base
3	Incorporated	Extra

Table 3: Ariah Park, Coolamon and Dirnaseer treatment table

2	3	1		3	2	1
3	1	2		1	3	2

Table 4: Trial plan Ariah Park

3	1
1	2
2	3
1	2
2	3
3	1

Table 5: Trial plan Dirnaseer

2
1
3

Table 6: Trial/demonstration plan Coolamon

Picture 2: Paddock scale trial at Dirnaseer, Strip 4 N showing post harvest incorporation and nutrient application. Incorporated strip foreground, intact buffer strips on right and left and reps of trial in background.

Results & Discussion

a. Small Plot Trial

Harvest yield results for the small plot trial at TAIC from 2012, 2013 and 2014 have been analysed and are summarised in Table 7.

Treatment	2012 – Wheat Yield (t/ha)			2013 – Wheat Yield* (t/ha)			2014 - Canola Yield ** (t/ha)		
Extra NPS timing	Harvest	Sowing		Harvest	Sowing		Harvest	Sowing	
	2.8	2.8		3.2	3.1				
Stubble	Incorp	Intact	Rem	Incorp	Intact	Rem	Incorp	Intact	Rem
	2.8	2.7	2.8	3.1	3.1	3.2	2.5	2.5	2.5
Nutrients	Base	Extra		Base	Extra		Base	Extra	
	3.0	2.7		3.1	3.2		2.4	2.6	
Grand mean	2.8			3.1			2.5		
Lsd	0.145			0.085			0.48		

Table 7: Small plot trial Yield Data 2012, 2013 & 2014 TAIC * CV for 2013 4.6 **CV for 2014 4.1

Timing of nutrient application and stubble management had no impact on yield in 2012, 2013 and 2014. Analysis showed that there was a small but significant negative effect on yield by adding extra nutrients in 2012, a small but significant positive effect on yield in 2013 and no effect in 2014. Although the result in 2014 may have been confounded by indeterminate variation in yield across the trial unrelated to treatment or trial protocol generating some outlying values.

Picture 3: Small plot trial TAIC, 2014 Canola crop Plot 5 Stubble removed, fertiliser treatment: extra nutrients post harvest.

b. Paddock Scale Trials

Harvest yield results for the paddock scale trials at Ariah Park and Dirnaseer in 2013 have been analysed and are summarised in Table 8.

In the paddock trials at both Ariah Park and Dirnaseer there was no significant difference in yield between the treatments. Both trial paddocks were canola in 2013 with yield at Ariah Park depressed due to frost damage and the dry finish to the season.

Plant establishment, NDVI scans and grain yield for the paddock scale trial at Dirnaseer in 2014 are summarized in Table 9. Plant counts in the incorporated treatments were lower than the intact (retained) stubble treatment due to the sub optimal operation of the disc seeder at sowing resulting in deeper seed placement than would normally occur. The impact of the disc seeder on plant emergence can be seen in Picture 4. NDVI scans in early September showed that the addition of nutrients may have had an influence on early vegetative growth despite the incorporated + nutrients having lower plant numbers – this did not translate into a significant difference in yield. The intact or retained stubble treatment had a significantly higher yield than the incorporated treatments. This may have been a result of moisture conserved due to not cultivating the soil with the Speedtiller.

Location	Crop	Stubble treatment yield (t/ha)			Mean of all treatments	L.s.d
		Retained	Incorp	Incorp + nutrients		
Ariah Park	Canola	0.9	1.0	1.0	0.97	0.28
Dirnaseer	Canola	2.5	2.6	2.6	2.5	0.29

Table 8: 2013 grain yield data for paddock scale trials at Ariah Park and Dirnaseer.

Stubble treatment	Dirnaseer Wheat 2014		
	Ave. plant counts/m2 (23/06/14)	NDVI (3/09/14)	Yield (t/ha)
Incorporated + nutrients	123.7	0.81	3.0
Incorporated - nutrients	123.1	0.77	2.9
Intact (retained)	132.7	0.75	3.6

Table 9: Plant establishment NDVI and grain yield 2014 paddock scale trial, Dirnaseer

Picture 4: Incorporated treatment at Dirnaseer paddock scale trial showing minor emergence issues due to pre cultivated treatments.

A dry short Spring across most of our region saw some treatment differences in mid October with the incorporated treatments showing signs of moisture stress. A Speedtiller was used for the incorporation process and resulted in top soil drying. This highlights how precious stored moisture can be when confronted with a dry finish to the season which can hasten senescence and crop maturity.

Picture 5: Dirnaseer paddock scale trial 15/10/14. Strip 2 (incorporated – nutrients), looking from N to S, you can see the crop is moisture stressed in comparison to the two intact stubble buffers either side.

Stubble treatment	Ariah Park	
	Canola Yield 2013	Wheat Yield 2014
Incorporated + nutrients	0.99 t/ha	2.64 t/ha
Incorporated - nutrients	0.96 t/ha	2.74 t/ha
Intact (retained)	0.94 t/ha	2.68 t/ha

Table 10: Yield Data 2013 & 2014. Paddock scale carbon trial, Ariah Park.

Yield data for the Ariah Park trial site in 2013 and 2014 is summarized in Table 10 and shows no significant impact of any treatment on yield.

Carbon Building Strategy Analysis

Possible costs associated with Carbon Sequestration program	Cost/ha
Nutrient purchase for 4t/ha wheat stubble	$55
Spreading nutrients	$12
Incorporation - speed tiller	$35
Total	$102

Table 11: Paul Breust FarmLink 2013

Table 11 provides a guide to the approximate costs associated with incorporation of extra nutrients on a commercial basis. A investment of approximately $100/ha would be required to increase soil C levels - this needs to be balanced against the benefits that higher soil carbon levels can have on productivity. These benefits arise from improvements in physical functions like water holding capacity, chemical functions and biological functions eg. Nitrogen mineralization.

Some yield mapping data and results for the paddock scale trials for Ariah Park and Dirnaseer are still being analysed and these data will be presented in future reports on this project.

Conclusions

Given that carbon sequestration is not an overnight process it is not surprising that there have been few significant results or trends to report on in either an intensive small plot or large paddock scale. It takes time for soil C to build up and measurable differences in yield from the soil C component may not be apparent initially.

Nutrient addition to balance the ratio of C:N:P:S has surprisingly had little impact on yield and this is possibly a desirable outcome as no difference between +/- nutrient treatments would indicate that the nutrients are available for stubble breakdown rather than going into the crop vegetative biomass.

In a paddock scale and across a whole farm there is a cost associated with the purchase, spreading and incorporation of nutrients which is over and above annual fertiliser crop allocations. This may prove a barrier to nutrient addition to stubbles to build soil C stocks. A research project funded by GRDC and Department of Agriculture (Federal) is determining the economic and environmental benefits of sequestering C on agricultural land in Australia.

Acknowledgements

Thank you to Harm Van Rees from Cropfacts for his assistance and advice with this project.

Thank you to Derek and Alexander Ingold and Geoff Tidd for hosting and conducting operations on these paddock scale trials. Thank you as well to Paul Bailes from Norwood Ag for the demonstration and use of the Speedtiller. This project was funded by Department of Agriculture 'Action on the Ground'.

Project Code: AOTGR1-955086-42