

Case Study: Biological Soil Amendment and Soil
Carbon Improvement

Region: Burdekin Qld

Land Use: Intensive Vegetable Farming

GPS Reference: 19 42.916 147 16.154

19 43.371 147 16.029

Fig 1 Data Summary

Data Summary			
	12 Nov 2009		
	Untreated Soil	Treated Soil	Change
Date of Sample:	12 Nov 2009		
Treatment Start:	Oct 2006 (3 Years prior)		
Location of Farm	Burdekin River Plain		
Land Use	Intensive Farming	Vegetables	
Predominate Soils	"Burdekin Sand"	Unstructured Sand	
Climate	Dry Tropics		
Soil Structure:	Fine Sandy Loam	Silty Loam	
Total Organic Carbon	0.35%	1.13%	0.78% of Soil Mass
Tonnes Carbon/Ha	1.5 Tonnes/Ha	16.95 Tonnes/Ha	11.7 T/Ha
Change Per Year	(Per Hectare Annualised)	Rate of Carbon increase	3.9 T/Ha/Annum
Available P	67.6 mg/kg	242 mg/kg	+258%
Water Holding at Sample	5.3%	12.9%	+143%
Savings in Fertiliser	200 kg P/ha 180 kg N/ha	110 KG P/ha 134 kg N/ha	-45% -26%
2008/2009 Fertiliser Cost	\$900/ha	\$545/ha	-\$355/ha

Fig 2 Soil Structure



Program Description

A program of soil amendment using recycled vegetative matter and incubation of specific soil inoculants was conducted over a three year term from 2007 to 2009. It has been postulated that biological soil amendments as part of a program of changed land management do nothing to bring about improvements in total reserves of soil carbon and therefore represent merely an extra cost to farmers (Grace et al 2008 and 2009). It has also been suggested that building humus and other soil carbon in soil requires additional fertiliser input and will therefore cost farmers money by causing capture of inputs they pay for (Passioura et al 2009 and 2010).

This program set out to test these hypotheses and to ascertain the relative cost/benefit relationship accruing from changed land management practices including biological amendments aimed at development of an improved soil carbon reserve. The program specifically implemented changed land management practices around the quantum of use of chemical fertiliser inputs and tillage practices and the inclusion of biological amendments in an intensive vegetable farming operation and measured impacts on global operative elements (gross yield and total input costs per hectare) and specifically on soil carbon enhancement. The farmer was particularly interested initially only in building soil carbon and the impacts of biological amendments on this. He saw improved soil carbon reserves as more important than cost factors. However, as the program progressed it became obvious that reductions in input costs were also very important to the operation. The program took the view that the total cost of inputs, including soil amendments in treated zones should not exceed those in control zones. Discrete production zones were identified which allowed specific comparison of land use methodologies in a defined area while monitoring was also conducted at a range of sites located across an operation covering 300 hectares in total.

Control areas (having no change in land management practice) were maintained. Crop yields were compared over the term and testing was conducted to measure soil values for Total Phosphorous, Total Organic Carbon,

Total Carbon and Total Moisture. Product suppliers and agents were excluded from the testing process and all soil sample analysis was conducted independently by NATA approved laboratories.

Farming operations continued on both control and test areas unabated throughout the period and followed normal crop rotations and fallow cycles for the farming operation. Fertilisation and irrigation were both performed via trickle irrigation and were carefully monitored and managed throughout in line with normal procedures for such farming operations. Standard agronomic testing underpinned fertiliser usage patterns throughout the trial period in both control and test zones.

Data was averaged over treated zones and over control sectors to give sampling results. Representative soil sampling was conducted across the site and at GPS located sites on the property in both control and treated sectors.

Crop Yields:

Year	Gross Yield Control (Tonnes)	Tonnes/Ha control	Gross Yield Treated (Tonnes)	Tonnes/Ha Treated	Difference
2007	166	20.5	229	28.3	37.95%
2008	162	20.0	174	21.5	7.41%
2009	258	31.9	298	36.8	15.50%
3 Year Average	195	24.1	234	28.9	20.00%

On average, crop yield improved in treated areas by 20% over the trial period. Tonnages are combined pumpkin, corn and beans to give total crop weight. Crop rotation within the period ensured a distribution of crop types across farm sectors over the period. While these results were pleasing for the farmer, it was considered that more detailed work should be done to show changes in yield in individual crops.

Input Costs:

Year	\$/Ha control	\$/Ha treated	Difference
2007	1606	1640	-2.11%
2008	1730	1730	0.0%
2009	1595	1205	24.45%
3 Year Average	1644	1525	7.24%

Treated Sector input costs include fertiliser and all other input costs together with the cost of manufacture of bio-fertiliser made from crop residues on site. This includes the collection cost of the organic waste and the input cost of the discarded fruit used to incubate bio-fertiliser. Cost of inoculants and other biological inputs is also included. Untreated sector input costs include fertiliser and all other input costs. A dramatic reduction in input costs was noted in the Treated Sector in year 3. While this was pleasing for the farmer, it was considered that more work should be done to identify specific areas (other than fertiliser alone) in which cost reductions have occurred. Of particular note was a dramatic reduction in the agronomic recommendation for application of Phosphorous on the treated sector particularly in year 3. At the end of the trial period, despite having reduced application of P to treated sectors to close to zero, a recommendation to apply no Phosphorous for two years to treated sectors was received. This factor represents a specific, measurable cost advantage arising from the program's implementation and provided the largest contributor to the cost savings of \$355 per hectare in

fertiliser alone which were experienced in treated over control sectors in the third year of the program. In total a 38% reduction in fertiliser usage was experienced in treated sectors over untreated sectors in the 3rd year of the program's operation.

Soil Structure change

A clear difference in soil structure and quality was noted over the term of the study (see figure 2). In line with the measured improvement in soil carbon reserves, a change in soil ped formation and in the prevalence of soil interspaces was obvious. This structural change was reflected in soil categorisation which moved from unstructured fine sandy loam to a silty loam over the three year term. Colour and texture of the soils also showed clear differences.

Secondary benefits which have accrued in treated sectors include an improved ability to hold moisture and conversely an increased ability to access and work soils immediately following heavy rainfall periods. It was noted that treated sectors could be accessed and effectively worked three to four weeks earlier than untreated sectors. Ponded surface water was observed to be considerably less in treated sectors while water retention in drier periods was dramatically improved.

Increased total biomass under some crops

Significantly increased levels of biomass were observed on treated sectors during pumpkin crop rotations. In pumpkin crops this was most evident where robust biomass was present at harvest on treated sectors to a height of approximately 900mm throughout. This vegetative matter was dense and in fact presented an imposition at harvest as it prevented visual inspection of the crop for harvest. A technique to manually knock down this vegetation was devised which was overlaid on standard harvest practices. Pumpkin vines at harvest were robust and still growing. Some ratooning was noted following harvest. A significant volume of vegetative matter persisted on the ground surface following harvest in pumpkin crops on treated sectors. This factor was not considered in overall input values for treated sectors, and it was recommended that more work should be done to ascertain nutrient contributions to subsequent crops from this biomass itself.

On untreated sectors, pumpkin crop vegetative matter was rarely above 300mm and was significantly less dense. Most vegetation and specifically pumpkin plants typically died off prior to harvest leaving minimal vegetative biomass on the ground surface at harvest. It was observed that the die-back of biomass on untreated sectors coincided with reduced soil moisture in these sectors later in the crop cycle.

Soil Carbon reserves

Soil testing and observable changes in soil structure and type confirmed a significant improvement in soil carbon reserves which occurred during the trial period on treated sectors. No improvement was noted in control sectors over the same period. It was significant that improvements in soil carbon were relatively consistent on all treated sectors and across the three year term regardless of differences in climatic conditions, precipitation and crop rotation throughout the period. Specifically, it was noted that the averaged increases in soil carbon were not more pronounced where pumpkin crops with higher biomass were grown.

The measured increase in total organic carbon across all treated sectors was significant and readily visible on even a cursory inspection of the property. Due to the low base of soil carbon reserves and the particular quality of the predominant soils of the area, combined with tropical climatic conditions, this increase in carbon was thought to

be impossible and the farmer reported that all previous efforts to improve soil carbon on the site over the past 20 years had failed.

Key Land management changes

The key land management changes implemented on treated sectors only are described in the following table.

Practice	General Description
Reduced Tillage	Tillage was completed only once per year to 200mm depth. Weed Scratching to 30mm also performed at mid-cycle
Reduced Fertiliser Input	Minimum 30% reduction of fertiliser input – this varied year to year as to which element was reduced with Nitrogen reductions prominent in years 1 and 2 and Phosphorous reduction predominant Year 3 Maximum total reduction of 38% by weight was achieved in year 3
Addition of Bio-Fert	150 litres per hectare of Recycled crop residues incubating VRM Photon Seeder and VRM Photon Starter were used in each crop cycle
Addition of Inoculants	VRM XLR8 N and VRM XLR8 Ca were used at 10 Litres per hectare per season
Manual Bio-mass knockdown	A manual slashing of extended biomass in Pumpkin crops occurred at harvest. This involved cutting biomass with a wire rope towed between two tractors. Biomass was not collected from the surface.

Summary of observations

Soil texture and quality were obviously improved in treated sectors over the period. An observed improvement in water handling capacity of the soil (both during wet and dry periods) was of particular interest to the farmer. Early access to wet ground provided a significant benefit in ground preparation. Similarly, the retention of moisture during dry/drought conditions at harvest provided significant relief and allowed a reduction of irrigation on treated sectors. Measurement of the quantum of reduced irrigation was not an object of this study and it is recommended that this element be further explored in a future study.

A significant improvement in soil carbon levels was noted in treated sectors over the course of the study. This improvement is well in excess of rates of improvement thought possible in similar soils and in intensive cropping. The improvement occurred equally in areas where extended biomass growth was observed and in areas where biomass growth was unchanged leading to a conclusion that while an improved soil carbon reserve may allow support of extended biomass in some crops, the biomass addition itself is not necessarily a requirement for improvement of the soil carbon reserve.

Global yields were at least maintained (and in fact improved) throughout the period on treated over untreated zones while global costs trended lower on treated over control zones as the program went on. This gives rise to a refutation of the premises put forward by Grace et al and Passioura et al on the grounds that:

- amendments were a key point of difference in management of treated over control zones
- addition of amendments did not result in either yield decline or additional cost and
- Soil Carbon reserves improved significantly following addition of amendments and not elsewhere.