Sweetpotato soil surveys

PW17001 Final report Appendix 5 Integrated pest management of nematodes in sweetpotato

Mary Firrell August 2023

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Queensland Government

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The Department of Agriculture and Fisheries proudly acknowledges all First Nations peoples (Aboriginal peoples and Torres Strait Islanders) and the Traditional Owners and Custodians of the country on which we live and work. We acknowledge their continuing connection to land, waters and culture and commit to ongoing reconciliation. We pay our respect to their Elders past, present and emerging.

Contents

List of images

List of tables

List of figures

Sweetpotato soil surveys

Summary

Part A: Summary grower surveys

Introduction

At the commencement of this project, sixty soil samples were taken from commercial sweetpotato farms across east coast growing districts and sent to the Department of Environment and Science (DES), Chemistry Centre for analysis.

Methodology

Analyses undertaken were, pH, Electrical conductivity (EC), Chloride (Cl), Nitrate- Nitrogen (NO_3- N), Total Organic Carbon (TOC), Potassium Permanganate Oxidisable Carbon (POxC), (PPOC), Total nitrogen (TN), Colwell Phosphorous (P) + phosphorus buffer index (PBI_COL) and Particle size analysis.

Results and discussion

Results indicate there is a wide range of soil types that support sweetpotato production. Particle size analysis showed these sixty soils had clay contents ranging from a low of 1.2% to 72% and fine sand content ranging from 6% to 57% across all sites. The anticipated correlation between low numbers of nematodes and high clay content soils hasn't been encountered in this set of samples. Ferrosols are a favored soil for sweetpotato production in Australia, and though these have a clay content of over 50%, they have an open physical structure which is conducive to root-knot nematode survival and reproduction.

Total Organic Carbon (TOC) in the two main growing areas ranged from 0.21% to 2.35% in Bundaberg and 2.00% to 3.72% in Cudgen. Results were sent to individual growers along with a soil results interpretation guide, prepared by team members. See appendix 5.

Key Points

- A wide range of soil types support sweetpotato production in Australia.
- The average TOC % is higher in Cudgen, due in part to cooler temperatures and higher rainfall.
- TOC results vary widely between farms due to the stage of the crop cycle when sampling occurred, and to variations in grower management practices.

Part B: Summary baseline Carbon surveys

Introduction

As part of this project, the team established a long term trial at Bundaberg Research Facility to investigate the use of organic amendments and composts to improve soil health and suppress root knot nematodes. Total Organic Carbon (TOC) results in this long term trial initially improved, however plateaued in the early stages of the trial. As a comparison between maximum TOC levels in the long-term trial, samples were taken from nearby undisturbed areas.

Methodology

Soil samples were taken to a depth of 10cm, as this reflects the sampling depth for the long term trial and analysed for TOC at DES. Samples were taken from protected remnant vine scrub and an undisturbed tree line at BRF and from a best practice growers farm < 10 km from BRF.

Results and discussion

The sample taken from the protected remnant vine scrub, gave a result of 7.22% TOC. This area has not been disturbed since white settlement and should have the highest possible carbon storage potential for the area.

The sample taken from the undisturbed tree line established at least 30 years ago, gave a result of 5.22% TOC and a sample taken from a best grower practice farm, gave a result of 1.85% TOC. This compares to levels ranging from 1.86 – 2.43% in the amended treatments of the long term trial.

Introduction

At the commencement of this project, sixty soil samples were taken from commercial farms across east coast growing districts and sent to the Chemistry Centre at the Department of Environment and Science for physical and chemical analysis.

Results were compared to nematode counts within the project, and a copy of the soil test specific to each farm was sent to that grower along with an interpretation guide (see example below)

In 2021, samples were also taken from undisturbed sites close to the Bundaberg Research Facility as a comparison with the long-term trial at BRF.

Image 1 Survey soil samples. Sweetpotatoes are grown on a range of soil types.

Methodology

Meetings were held with the Department of Environment and Science (DES), Chemistry Centre staff in late 2019 to determine the most useful analyses that may correlate soil health with nematode populations.

The suite of analyses most suited to our needs was determined as the following;

- 1:5 water extractions: pH, Electrical Conductivity (EC), Chloride (Cl) and Nitrate- Nitrogen (NO_3- N)
- Total Organic Carbon (TOC)
- Potassium Permanganate Oxidisable Carbon (POxC), (PPOC)
- Total nitrogen (TN)
- Colwell Phosphorous (P) + phosphorus buffer index (PBI_COL)
- Particle size analysis (PSA)

Each sample was also tested using the Solvita®CO2 Burst method for determining soil microbe respiration as an indication of microbial population levels. This burst test simulates a rain event (drying – wetting) by activating soil microbes which then respire and produce a burst of CO_2. Test results were sent to growers, however this test method wasn't continued past the initial stage of the project.

Part B: Summary baseline Carbon surveys

As a comparison between maximum TOC levels in the long-term trial, samples were taken from nearby undisturbed areas and sent to the Chemistry Centre for TOC analysis. A sample was taken from an area of protected remnant vine scrub, at the Bundaberg Research Facility, another sample taken from an undisturbed tree line established at least 30 years ago and another from a nearby good practice grower farm.

Image 2: Vine scrub sampling site at BRF, TOC =7.22%

Image 3 Undisturbed tree line at BRF with a TOC result of 5.22%

Image 4 Grower rotation cropping with a nematode resistant sorghum crop

Results and discussion

Soils analyzed, indicate that there is a wide range of soil types that support sweetpotato production, with clay content ranging from a low of 1.2% to 72% and fine sand content ranging from 6% to 57% across all sites. The anticipated correlation between low numbers of nematodes and high clay content of soils hasn't been encountered in this set of samples. Ferrosols are a favored soil for sweetpotato production in Australia, and though these have a clay content of over 50%, they have an open physical structure which is conducive to root-knot nematode survival and reproduction.

An extensive range of soil properties and chemistry was reported for the survey of grower soils. The samples were taken from different farms at varying times in the cropping cycle and under varied management regimes so the large variation in values is to be expected.

Table 1 Range of soil chemistry values from grower soil surveys

Range of values for grower soils			
	Lowest	Highest	Mean
pH	5.02	7.85	6.48
EC (dS/m)	0.02	0.42	0.11
P (mg/kg)	4	276	104
Cl (mg/kg)	21	362	70
NO3-N (mg/kg)	1	87	11
TOC (%)	0.21	3.7	1.64

Total N (%)	0.016	0.632	0.15

Total Organic Carbon (TOC) in the two main growing areas ranged from 0.21% to 1.93% in Bundaberg and 2.00% to 3.72% in Cudgen. The higher result for Cudgen soils can be due to cooler temperatures and higher average rainfall than that in Bundaberg.

Table 2 Total Organic Carbon values in grower's soils

Range of TOC values for grower survey soils (%)				
	Lowest	Highest	Mean	n
Cudgen	2.00	3.72	2.68	16
SEQ	0.28	1.78	0.99	6
Bundaberg	0.21	1.93	1.31	38
CQ	1.04	1.84	1.32	7
NQ	1.65	2.27	1.96	2
Pasture Cudgen		7.71		1
Pasture Bundaberg	2.18	4.13	3.16	2

Results of the TOC survey of undisturbed sites reported 7.22% TOC for the area of protected remnant vine scrub. This area has not been disturbed since white settlement and should have the highest possible carbon storage potential for the area.

A sample taken from an undisturbed tree line established at least 30 years ago, gave a result of 5.22% TOC. This tree line had a large amount of dry leaf litter on the surface of the soil which is generally left untouched although the area is exposed to strong sunlight.

A sample taken from a nearby, best grower practice, commercial sweetpotato farm gave a result of 1.85% TOC. A nematode resistant sorghum cover crop had been grown and rotary hoed into the paddock with a considerable amount of stubble incorporated into the soil.

The levels of 1.86 – 2.43% TOC in the amended treatments of the Intensive Trial compare well to these results, with the trial amendments giving higher results than good grower practice but obviously not achieving the levels of undisturbed soil.

Soil test results example letter sent to sweetpotato growers

Queensland Government

Department of
Agriculture and Fisheries

26 October 2023

Dear xxx,

Subject: Soil test results

Soil samples from your property were sent to the Department of Environment and Science at the Eco-Sciences Precinct, Dutton Park, as part of a survey of sweetpotato paddocks for project PW17001 (*Integrated pest management of nematodes in sweetpotato*). The aim of the survey is to investigate any correlation between soil characteristics and Root Knot Nematode (RKN) populations, and although there have been no apparent correlations, your soil results are attached for your interest.

Soils were dried and tested for the following:

- pH
- Conductivity (EC)
- Chloride (Cl)
- Nitrate-Nitrogen (NO3-N)
- Phosphorous (P)
- Phosphorous Buffering Index (PBI)
- Total Carbon (TC)
- Total Nitrogen (TN)
- Total Organic Carbon (TOC)
- Permanganate Oxidisable Carbon (POxC)
- Particle Size Analysis (PSA) Coarse Sand, Fine Sand, Silt and Clay

Your results along with an interpretation document accompany this letter.
If you require any further information regarding this matter, please do not hesitate to contact me on telephone 0428114140 or email Mary.Firrell@daf.qld.gov.au

Yours sincerely

Mary Firrell,
Senior Experimentalist,
DAF Gatton Research Facility.

Image 5. Example letter soil test results.

Queensland Government

Department of
Agriculture and Fisheries

Test	Unit	Block			
DAF reference		RL06	RL07	RL08	
pH	-	5.557	5.719	5.772	
Electrical Conductivity (EC)	dS/m	0.04	0.04	0.04	
Chloride (Cl)	mg/kg	22	<20	<20	
Nitrate-Nitrogen(NO3-N)	mg/kg	2	1	1	
Phosphorus (Colwell P)	mg/kg	73	104	137	
PBI Colwell		31	38	51	
Total Nitrogen (TN)	mg/kg	270	300	520	
Total Nitrogen (TN %)	%	0.027	0.03	0.052	
Total Carbon (TC)	%	0.48	0.35	0.72	
Total Organic Carbon (TOC)	%	0.422	0.374	0.614	
Permanganate Oxidisable Carbon(POxC)	%	0.023	0.029	0.027	
Coarse sand	%	51.4	44.1	38.9	
Fine sand	%	38.2	31.3	32.5	
Silt	%	6.1	7.6	12.7	
Clay	%	6.3	20	20	

DAF Reference	Sampling Site	Block Information
RL0778	55 Red Rd, Right hand side of driveway	Rotation crop; Sorghum
RL0779	Flower Rd next to strawberries	Sampled 3 weeks prior to harvest
RL0800	Gum Rd next to capsicums	Sampled at harvest

There is always some uncertainty in laboratory testing and the results above can have an uncertainty of ± 5-10%.

For your reference.
Total Organic Carbon (TOC) in the 36 Bundaberg samples analysed to date ranged from 0.21% to 2.35% for land cropped to sweetpotato. Two soil samples collected from an undisturbed pasture site had TOC levels of 4.13% and 2.18%.

Image 6. Example letter soil test results.

Soil Test Information Guide sent to growers.

The below soil test interpretation guide was provided to growers with their soil test results.

Soil test interpretation guide

The following information is a brief background on the tests conducted on your soil.

Through the soil surveys and testing conducted for this project we hope to understand any correlations between soil characteristics and nematode populations.

pH

This is a measure of the acidity or alkalinity of the soil and influences the availability of nutrients to the plants.

- pH <7 = acidic
- pH 7 = neutral
- pH > 7 = alkaline
- A pH range from 5.5 to 7.0 is suitable for most vegetable crops
- A pH of 5- 7.5 is acceptable for sweet potatoes with an optimal range of 5.5 to 6.5

Electrical Conductivity (EC).

This is a measure of the salts (or salinity) in the soil and is usually reported as deciSeimens/metre (dS/m)

In sweet potato production, yields can decline rapidly as salt levels rise. Below are the ranges at which yield is reduced.

Table 3. Electrical conductivity readings.

EC reading	Yield Impact
≤ 1.5 dS/m	satisfactory
1.5-2.4 dS/m	0-10% yield reduction
2.4-3.8 dS/m	10-25% yield reduction
3.8-6.1 dS/m	25-50% yield reduction

Chloride (Cl)

Chloride is an important nutrient for plant growth and health however it can also cause damage if levels are too high. Fertiliser and irrigation water quality are the usual inputs that affect soil chloride levels. Sweet potato specific information is difficult to find however in general discussion with an agronomist, it seems that levels < 250mg/Kg are considered harmless.

Nitrate- Nitrogen (NO3-N)

This is a measure of nitrogen that is in the easiest form for plants to use. Nitrogen can be present in other forms (e.g. Organic N) that are not immediately available to the plant. The advice from an experienced sweet potato agronomist is that an optimum level in sweet potatoes is <20 mg/Kg

Phosphorus

Colwell P (Phosphorus). This is a direct measure of the phosphorus in the soil in mg/kg but this alone doesn't indicate the availability of P to plants and must be interpreted in conjunction with PBI.

Phosphorus Buffering Index (PBI). Phosphorus Buffering Index (PBI) is an indication of a soils ability to bind and release P. Soils with a high PBI will bind P and make it unavailable for plant uptake and soils with a low PBI will bind only small amounts of P.

Total Nitrogen (TN)

This is a measure of all forms of Nitrogen (N) in the soil sample and is made up of Organic N, often in the form of crop residues which aren't immediately available to plants, Ammonium forms of Nitrogen and Nitrate-Nitrogen (NO3-N)

Total Carbon

Total carbon(TC) Is the sum of all the carbon forms and is made up of; Total Organic Carbon (TOC) + Total Inorganic Carbon (minerals e.g. Calcium carbonate) + Elemental Carbon (e.g. graphite or charcoal).

Total Organic Carbon (TOC).

Total organic carbon is a measure of the Carbon(C) contained within the soils organic matter and is made from plant, animal and microbial residues. It consists of different fractions of C, one which is very stable and doesn't change much over time, this is often referred to as Recalcitrant/Resistant Organic C (ROC) but the other two fractions can be influenced by farming practices such as cover cropping and reduced tillage. These other 2 labile fractions are often referred to as Humus Organic Carbon (HOC) and Particulate Organic Carbon (POC)

Total Organic Carbon = Recalcitrant Organic Carbon (ROC) fraction which has a turnover time of 2500 years + slower fraction (HOC) with a turnover time of 20–40 years + labile fraction (POC) that has a turnover time of 2–3 years

Permanganate Oxidizable Carbon or (POxC)

Labile carbon is also made up of different fractions one of which is termed Permanganate Oxidizable Carbon or POxC. It has been correlated with microbial biomass and is a potential indicator of microbial activity.

Particle Size Analysis (PSA)

This is a measure of soil texture and categorises the soil as Coarse Sand, Fine Sand, Silt and Clay. A soil texture triangle is a tool that can be used to classify your soil based on particle size distribution.

Using the soil texture triangle

The soil texture triangle, below, is used to convert particle size distribution into a recognised texture class for a soil based on the relative amounts of sand, silt and clay as a percentage.

Example A: – Sand 50% + Silt 30% + Clay 20% = SILTY LOAM
The grid on the triangle allows you to move to the left or the right of your position running parallel with either side of the triangle. It is best to start at the base with the sand. Position your finger along the base line at the 50% mark. Move your finger up the line running parallel with the right side of the triangle. Simultaneously use another finger to trace a line from the 30% silt mark until the two meet. Your two fingers will always meet at clay for the remaining percentage, in this case 20%. This is always the case that the first two sizes chosen will lead you to the third.
Example B – Sand 80% + Silt 5% + Clay 15% = SANDY LOAM
Trace your finger along the 80% sand line while simultaneously tracing another finger along the 5% silt line until the two meet. This should be where clay is 15%.
Ref:(**Katharine Brown** (The University of Western Australia) and **Andrew Wherrett** (Department of Agriculture and Food, Western Australia).http://soilquality.org.au/

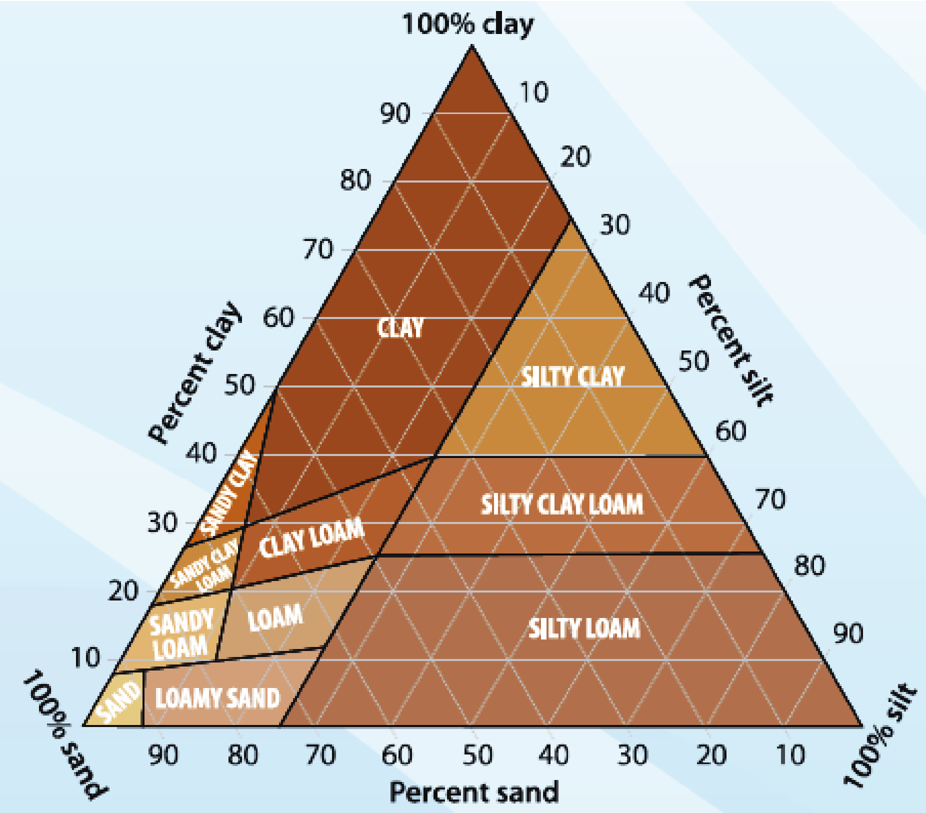

Figure 1 The soil texture triangle *Image adapted from Hunt and Gilkes (1992).* http://soilquality.org.au/

Further Reading.

The following references are general Australian soil references and although not specific to sweetpotato provide background information about soil characteristics and testing. The Nitrogen Book was written as a resource for grain growers but may be of interest.

Soil health for vegetable production in Australia—Part 4: Measuring soil health
https://www.daf.qld.gov.au/__data/assets/pdf_file/0011/77519/Soil-health-vegetable-production-Part_3a.pdf

The Soil Quality Website http://soilquality.org.au/

https://www.hort360.com.au/wordpress/uploads/Nutrient/Decision/Soil_Test_Interpretation_Guide_1.pdf

The Nitrogen Book. Principles of soil nitrogen fertility management in central Queensland farming systems.

https://www.daf.qld.gov.au/business-priorities/agriculture/plants/crops-pastures/broadacre-field-crops/cropping-efficiency/nitrogen-books

Hazelton P. and Murphy B. (2013) “Interpreting soil test results. What do the numbers mean?” CSIRO Publishing: Collingwood, Vic., Australia

Katharine Brown (The University of Western Australia) and Andrew Wherrett (Department of Agriculture and Food, Western Australia).http://soilquality.org.au/

Carbon Dioxide (CO_2) and Carbon (C) Test Result.

Carbon Dioxide (CO_2) as measured in the soil samples collected from your farm is an indication of biological activity within your soil.

We have used a test called the Solvita CO_2- Burst test where we have taken a subsample of your soil, warm dried it, added a measured quantity of water, a CO_2 probe and then incubated it for 24 hours. At the end of the 24-hour period we have read the colour change of the probe in ppm CO_2.

This burst test simulates a rain event (drying – wetting) by activating soil microbes which then respire and produce a burst of CO_2.

The following is a guide to interpreting the test result you have received for your soil.

Table 4. Carbon dioxide interpretation giude.

Level of CO_2-C as ppm	**Calibration to Suggested Soil Biological Fertility Classes and Soil Condition**
165 - 400	Unusual High-Biology Soil, High N-min Potential
70 - 165	Typical High Biology Soil, Strong N-min Potential
30 - 70	Medium Biology Soil, Some N-min Potential
12 - 30	Medium-Low, Low N-min Potential
5 - 12	Typical Low Biology Soil, Very Low N-min Potential
<5	Soil Very Low in Microbes, No N-min Potential

Adapted from Solvita Soil CO2-Burst Official Solvita Instructions Version 2016/1

The supplier of the Solvita test states:

"The quantity of CO2 evolved is proportional to microbial biomass. This burst of soil CO2 has been associated with positive nutrient fluxes and rapid availability to plants from mineralization". (Woods End Laboratories)

Carbon

A sample of your soil was sent to the Lismore laboratories of Southern Cross University.

The following table may be used as a guide to interpreting your test result.

Table 5 Range of Proposed rating levels for soil carbon to assess soil health or soil condition. *will depend on texture, soil sodicity and presence of free iron.

Level of Organic carbon (%) (g/100g)	Rating	Band	Interpretation*
<0.40	Extremely low	1	Subsoils or severely eroded, highly degraded surface soils
0.40-0.59	Very low	2	Very poor structural condition, very low structural stability.
0.60-0.79	Low L1	3	Poor to moderate structural condition, low to moderate structural stability.
0.80-0.99	Low L2	4	
1.00-1.19	Moderate M1	5	The following improve with increasing soil carbon levels: structural stability, pH buffering capacity, soil nutrient levels (especially nitrogen), water holding capacity
1.20-1.39	Moderate M2	6	
1.40-1.59	Moderate M3	7	
1.60-1.79	High H1	8	Good structural condition, high structural stability, pH buffering capacity, soil nutrient levels (especially nitrogen), water holding capacity
1.80- 1.99	High H2	9	
2.00-2.19	Very high VH1	10	
2.20-2.39	Very high VH2	11	

2.40-2.59	Very high VH3	12	Soils with very good soil structure and high buffering capacity with sufficient organic matter to decrease bulk density and improve water holding capacity
2.60-2.99	Very high VH4	13	
3.00-8.70	Extremely high	14	Soils obviously have high levels of organic matter (dark coloured, greasy to touch and large amount of organic material in the soil). Usually associated with undisturbed woodlands and forested areas.
>8.70	Organic soil material	15	Highly organic soil including peat.

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Katharine Brown (The University of Western Australia) and **Andrew Wherrett** (Department of Agriculture and Food, Western Australia).http://soilquality.org.au/