Department of Science, Information Technology and Innovation

RP155C: Sub-soil Constraints Mapping to Inform Nutrient Management in Cropping Systems Milestone 2 Report

Farm Nutrient Management Plan and Productivity Unit Yield Potential Concepts

Soil Processes, Landscape Sciences, Science Division

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Queensland Government

Prepared by

Philip Moody
Landscape Sciences
Science Division
Department of Science, Information Technology and Innovation
PO Box 5078
Brisbane QLD 4001

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The disaggregated soil data were provided as one of the project deliverables by Lauren O’Brien, an RP155C project team member.

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Contents

Summary

Four case studies in the Mackay district have been used to demonstrate the application of a Farm Nutrient Management Plan based on the principles of:

- determining the Productivity Unit Yield Potential (PUYP) of cane blocks on the farm from mill consignment or remotely sensed yield data;
- using PUYP to identify those areas with constraints to productivity;
- using fine scale disaggregated soils data and/or EM maps to identify the cause of the constraints;
- assessing management options for mitigating/ameliorating the constraints;
- adjusting N fertiliser product and application rate based on decisions about how the constraints might be managed.

The case studies demonstrate how the PUYP concept:

- can be applied at block or within block scale;
- can utilise multiple data sources: consignment or remotely sensed yield data, EM maps, and fine scale soil survey data;
- can guide adjustment of applied N rates that will either increase or maintain productivity provided management strategies are undertaken to minimise the loss of applied N;
- can increase nitrogen use efficiency and may reduce N fertiliser costs.

Applying the Farm Nutrient Management Plan and the associated PUYP concept implements several steps of the SIX EASY STEPS nutrient management program.

This information and concepts were presented and shared with Industry and Natural resource Management bodies at a stakeholder workshop in February 2015.

1. Overview of the concepts of a Property Nutrient Management Plan and Productivity Unit Yield Potential

1.1 Farm Nutrient Management Plan

The BSES-developed 'SIX EASY STEPS' (6ES) nutrient management program has provided the industry with a set of guidelines to manage inputs based on soil properties. The SIX EASY STEPS are:

1. Knowing and understanding our soils;
2. Understanding and managing nutrient processes and losses;
3. Soil testing regularly;
4. Adopting soil-specific fertiliser recommendations;
5. Using leaf analysis as a check on the adequacy of fertiliser inputs;
6. Keeping good records/modifying nutrient inputs when and where necessary.

In the case of nitrogen (N), crop N requirements for the entire farm are currently based on a target yield for the district (or in the case of the Burdekin, sub-district) called district yield potential (DYP) and a 1.4/1 multiplier (Schroeder et al. 2005). Discounts for in-season soil N mineralisation and other N sources are then made from the crop N requirement to give an N fertiliser recommendation.

Because block yields across a farm for the same season/crop class are likely to vary, there is an opportunity to refine the target yield of identified units on the farm based on their past performance over two or more crop cycles. This is the basic principle underpinning the concept of the **Farm Nutrient Management Plan** (Fig.1) that implements steps 1, 2, 3, 4 and 6 of the SIX EASY STEPS. The Plan provides for on-going monitoring and evaluation based on the simple N use efficiency (NUE) indicator of (kg applied N/tonne cane) or its inverse (tonne cane/kg applied N).

On a whole farm scale, a simple split into persistently higher and persistently lower performing areas might lead to two different target yields (termed **'Productivity Unit Yield Potential'- PUYP**). Similarly, if yield maps supported by EM mapping are available, it may be obvious that there are persistently higher or lower yielding areas either across sections of the farm, or within a block, providing opportunity for addressing identified yield constraints and/or variable rate fertiliser application to match the different PUYPs. The PUYP concept can therefore be applied at any scale- multiple blocks, single blocks or within blocks; it is simply identifying areas on the farm with similar yield potentials.

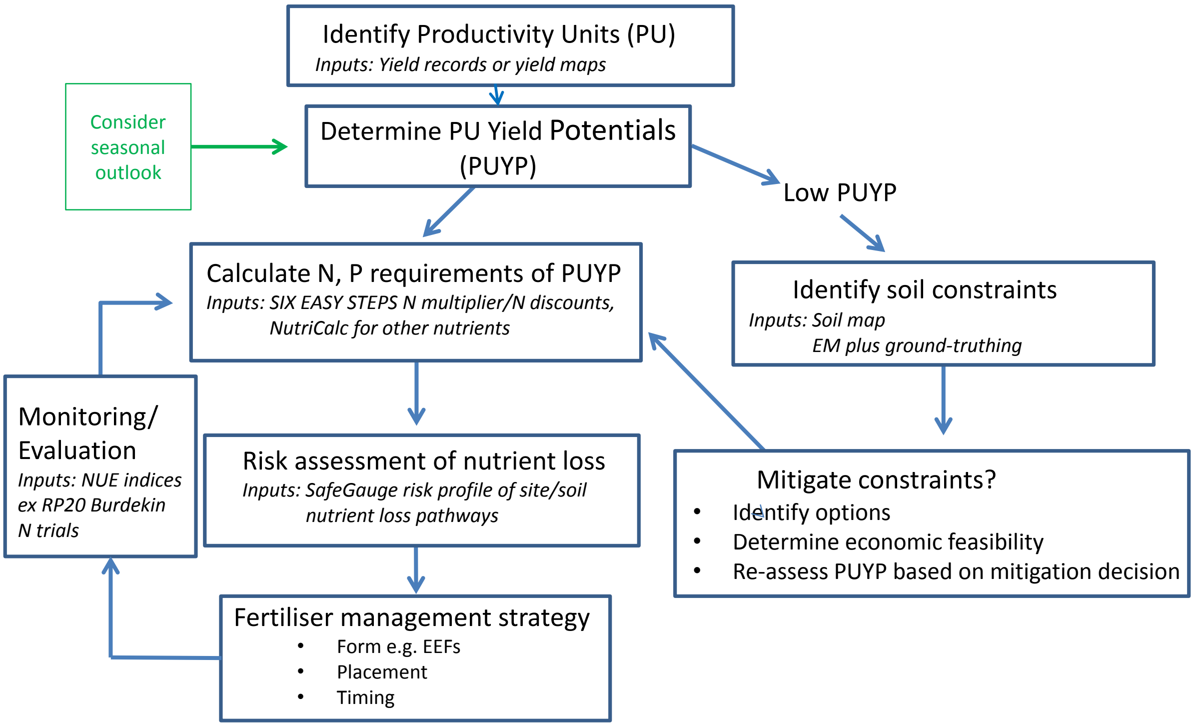


Figure 1 - Concept of a Farm Nutrient Management Plan

Where different PUYPs are apparent, this outcome should prompt an assessment of why one area is lower performing than another- is it soil type related, or is it due to sodicity, waterlogging, weed pressure, irrigation management or some other identifiable factor? If the causal factor/s can be identified, then the grower has the option of deciding whether to ameliorate (e.g., gypsum application to manage sodicity) or mitigate (e.g., improved drainage or raised crop beds to manage waterlogging) the problem, or just accept that the yield from that area will always be lower than other areas on the farm. In either case, the outcome will be a re-assessment of inputs and management strategies to achieve PUYP and maximise fertiliser N uptake by the crop.

1.2 Calculating Productivity Unit Yield Potential

For the purpose of this report, PUYP is calculated using the following formula:

PUYP = (Mean yield + 2*SE)

where SE = Std Dev/$\sqrt{n}$, and n= population of the sample

For normally distributed data (which cane yield from any designated area is assumed to be), (mean yield $\pm$ 2*SE) captures 95% (P=0.05) of the variation in yield; consequently only in 1 year out of 40 (P=0.025) would the yield of the productivity unit be expected to be higher than its PUYP. PUYP therefore estimates a target yield that represents maximum productivity and is achievable based on past performance.

1.3 Sources of yield data

1.3.1 Consignment Data

PUYP at a farm or block level can be calculated by analysing consignment records as supplied to the processing mill. In the majority of cases, the consignment data will detail the farm number, block number, cane variety and age as well as the date cut. It must be noted that while consignment details are available for all farm deliveries made to a mill, the accuracy of the information provided can vary greatly, especially block details.

In this report, block yield data generated by consignment has been analysed to calculate PUYP (at a block level) for the years 2001 to 2015 (inclusive). PUYP calculations have been split into two (2) crop class categories: young cane (Plt, 1st Ratoon, 2nd Ratoon) and older cane (3rd ratoon and older).

1.3.2 Satellite data

Satellite-derived data to calculate yield estimates for sugar cane crops in the Mackay district have been available from 2001 onwards. The process of calculating yield involves converting the raw satellite data into a known vegetation index and then using algorithms tailored to suit individual cane varieties to convert vegetation index values to cane yield. In this report, yields derived from satellite data have been used to calculate block level PUYP for younger cane (Plt, 1st Ratoon, 2nd Ratoon) only.

The benefit of satellite data is that yields can also be calculated for every pixel contained within a block which allows for a more refined analysis of sub-block PUYP. However, due to the highly variable growing conditions from year to year, evaluating the temporal (year-to-year) variation of yield distribution within cane blocks is an essential step in defining areas with potentially high and low yields. Several approaches can be used to evaluate temporal effects on yield. The approach used here is to calculate the relative (normalised) yield for each pixel with this relative yield defined as the ratio of the actual yield of the pixel to the block average for those years where the cane class matched plant, 1st or 2nd ratoons. The creation of sub-block yield zones is then achieved by grouping the relative yield pixels of similar values from the relevant years (Markley and Hughes, 2013).

1.4 Calculation of crop N requirement

Once the farm PUYPs are decided, crop N requirements can then be calculated using the 1.4/1 multiplier. This multiplier has been shown to be appropriate at block scale for the Burdekin district (RP20 results: Moody and Connellan, 2018) and will also be evaluated in other districts by N rate field experiments currently being carried out in projects funded by SRA, NESP, and the RRD4P Program.

2 Case studies

Four case studies have been undertaken in the Mackay district to apply the principles underpinning the Farm Nutrient Management Plan concept based on PUYP (Fig. 1), and to compare the outcomes in terms of cost and environmental impacts. The case studies comprise examples of PUYP varying between blocks of different soil types (1 study) and within blocks where sodicity (2 studies) or intermittent waterlogging (1 study) have been identified as the causes of yield constraints. Simple gross margin analyses has been applied to estimate the return from ameliorating/mitigating the constraint, and to compare fertiliser costs associated with using PUYP rather than DYP as the target yield.

2.1 Case Study 1

Locality: Dawlish

Farm: 4258

Scale: Within block

Block: 4-1

Lat/Long: -21.38384S 149.13467E

2.1.1 Soil type

Existing mapping (1:100 000 scale) Holz and Shields (1985):

Map unit #2046.

This map unit is labelled Sunnyside, but is defined as an area likely to contain similar proportions of Sunnyside (Grey Chromosol), Calen (Brown/Grey Sodosol) and Brightley (Grey Vertosol) soils. Block 4.1 is only a small portion of the total map unit, in a lower part of the landscape, near a circular shaped dam.

Draft disaggregated soils mapping (30m pixel resolution):

The disaggregated soils mapping suggests that the block is dominated by Calen and Brightley soils, with only a limited area of Sunnyside. Figure 2 shows the case study area is mostly mapped as Calen.

Calen soils are described (Salter et al., 2015) as being slowly permeable and imperfectly drained and therefore prone to intermittent waterlogging. Subsoils are sodic to strongly sodic at depth which can result in restricted rooting depth. Topsoils are hard-setting and prone to compaction. The most likely pathways for N loss are by runoff and/or denitrification during periods of waterlogging.

Brightley soils are described (Salter et al., 2015) as having low permeability, poor drainage and can remain wet for long periods. Topsoils are weakly self-mulching and crack when dry. There is a high risk of compaction if these soils are tilled or trafficked when too wet. Subsoil sodicity can sometimes occur. The most likely pathways for N loss are by runoff and/or denitrification during periods of saturation.

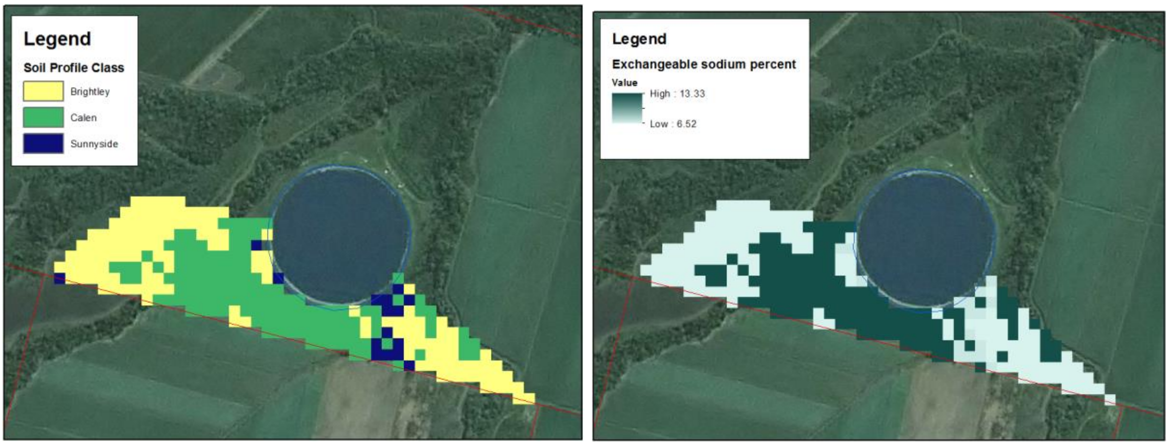


Figure 2 - (Left) Draft disaggregated soil mapping for Farm 4258, Block 4-1. The mapping depicts the most probable soil profile class per pixel, modelled from existing mapping and correlations with environmental data (e.g. remotely sensed terrain data). (Right) Predicted exchangeable sodium (as percentage of total exchangeable cations), 60-100cm depth range. Predictions are made using analytical data from sites considered typical of the mapped soil profile classes.

2.1.2 Yield data

Table 1 - Cane variety, crop class and yield (tonnes cane/ha) as derived from mill consignment data (2001 to 2015)

Year	Variety	Crop class	Consignment yield (tc/ha)
2001	Q124		
2002		F	
2003	Q170	Plt	55
2004	Q170	1R	70
2005	Q170	2R	66
2006	Q170	3R	70
2007	Q170	4R	65
2008		F	
2009	Q226	Plt	54
2010	Q226	Standover	
2011	Q226	1R	55
2012		F	
2013		F	
2014	Q208	Plt	71

2015	Q208	1R	57

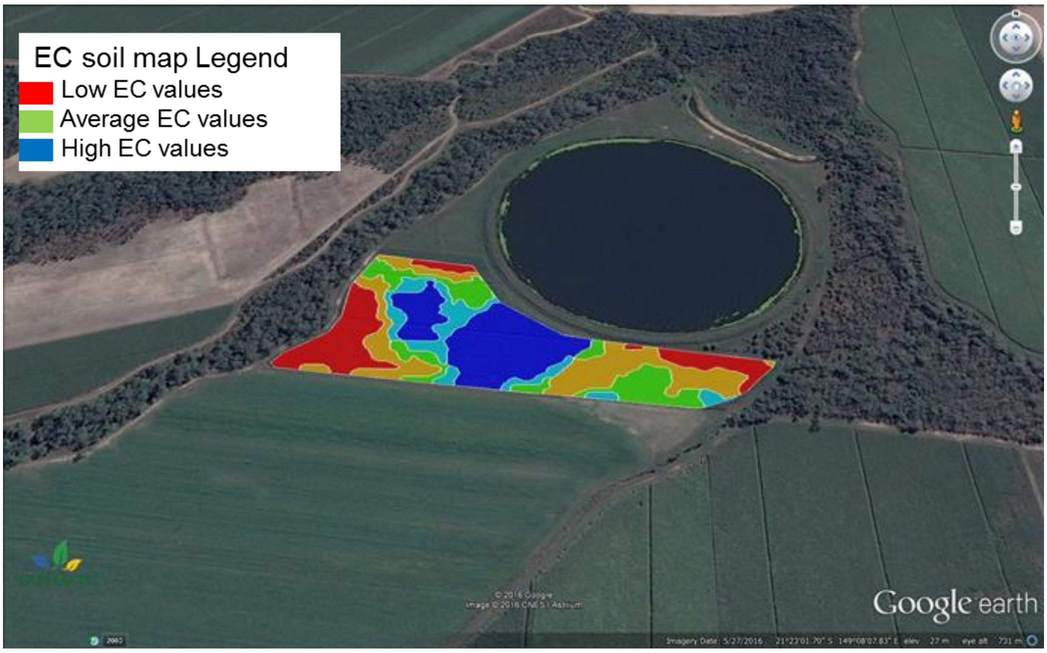
Table 2 – Block PUYP (tonnes cane/ha) derived from mill consignment data

Crop class	Mean (tc/ha)	StdDev	Count	StdError	PUYP (2 StdErr) (tc/ha)	Max recorded yield (tc/ha)
Plt, 1R, 2R	61	7.56	7	2.86	67	71
3R, 4R	68	3.54	2	2.50	73	70

Table 3 - Block PUYP (tonnes cane/ha) calculated from satellite data

Crop class	Mean (tc/ha)	StdDev	Count	StdError	PUYP (2 StdErr) (tc/ha)	Max estimated yield (tc/ha)
Plt, 1R, 2R	78	16.22	7	6.13	90	87

Whether estimated from consignment data or remotely sensed data, PUYP is close to the maximum recorded or estimated yields obtained over the twelve year period.



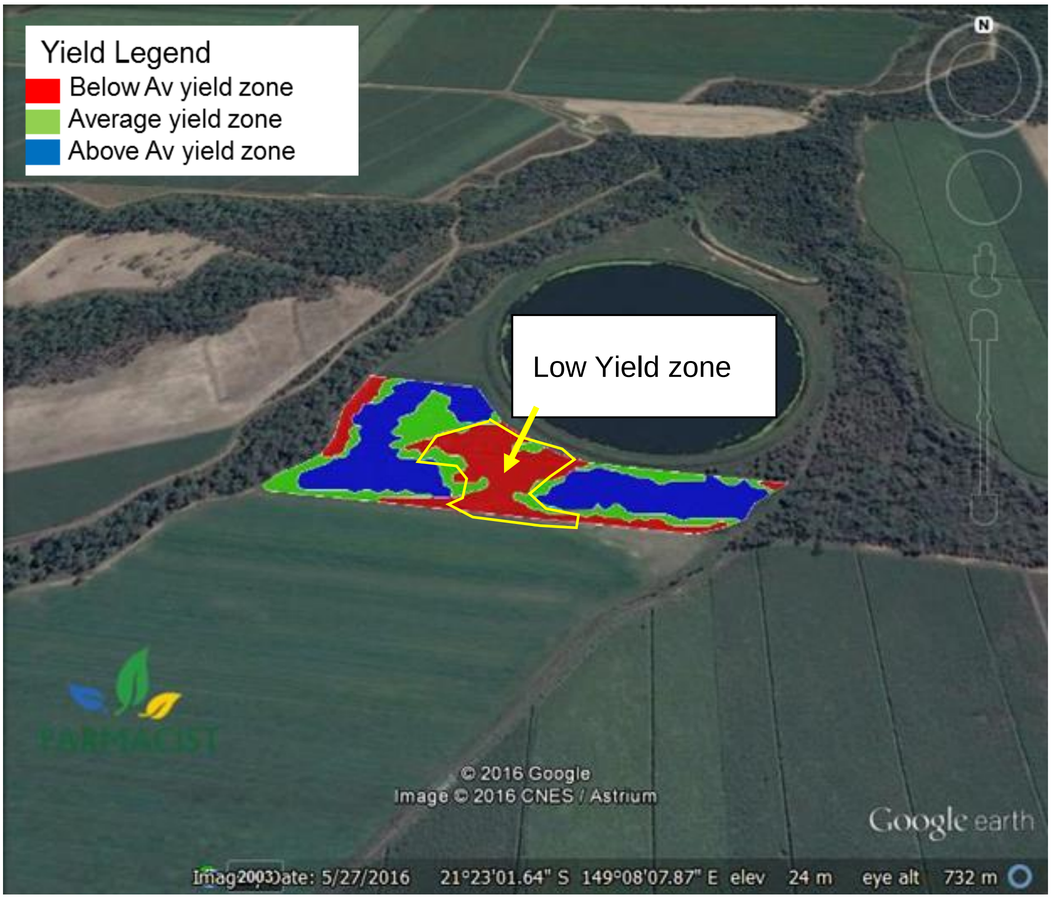


Figure 3 – EC_a (Apparent Electrical Conductivity) map obtained using an electro-magnetic induction instrument (EM38 model) (Top) and satellite yield mosaic map (Bottom) for Case Study Site 1

The results of soil samples collected from within the block indicate the extent of the sodicity issue: sample # 21522526 was collected from within the low yielding zone of the cane block and sample

21522527 was collected from within the high yield zone. In the 0-25cm soil, the low yielding zone had an exchangeable sodium percentage (ESP) of 25 compared to an ESP of 1.9 in the high yielding zone (Table 4).

Table 4 - Soil analysis results

Lab Sample Id	21522526 (low yield)	21522527 (high yield)
Paddock Name	MKY-04258A-04-01	MKY-04258A-04-01
Sample Depth (cm)	0 - 25	0 - 25
Sampling Date	16/09/2014	16/09/2014

Analyte / Assay	Units		
Soil Colour		Grey	Grey
Soil Texture		Clay Loam	Clay
pH (1:5 Water)		7.1	5.6
pH CaCl		6.3	4.5
EC_{SE}	dS/m	3.7	0.1
EC (1:5)		0.46	0.02
Chloride	mg/kg	550	18
Organic Carbon (OC)	%	1.3	0.6
Nitrate Nitrogen (NO_3)	mg/kg	2	2
Phosphorus (Colwell)	mg/kg	140	16
Phosphorus (BSES)	mg/kg	330	21
PBI-Col		23	47
Potassium (Amm-acet.)	Meq/100g	0.54	0.06
Potassium	%	5.4	1.7
Potassium (Nitric K)	Meq/100g	3.6	0.51
Available Potassium	mg/kg	210	22
Sulphate Sulphur (MCP)	mg/kg	33	4.8
Cation Exchange Capacity	Meq/100g	9.94	3.28
Calcium (Amm-acet.)	Meq/100g	3.6	2.1
Calcium %CEC	%	36	64
Magnesium (Amm-acet.)	Meq/100g	3.3	0.74
Magnesium %CEC	%	33	23
Sodium (Amm-acet.)	Meq/100g	2.5	0.06
Sodium % of Cations (ESP)	%	25	1.9

A strong relationship exists in mapping patterns of both yield values and deep EC_a values obtained by on-ground electro-magnetic induction mapping. Above-average yield zones are evident where EC_a values are low, and conversely low yield zones correspond with high EC_a mapping patterns (Figure 3). In this case, the high EC_a sector where yield is constrained is identified as being high ESP (Table 4).

Table 5 - Zone PUYP (tonnes cane/ha) from satellite data (Block PUYP* Zone ratio)

Yield Zone	Block PUYP (tc/ha)	Zone Ratio	Zone PUYP (tc/ha)
Low	90	0.75	68
Average	90	1.00	90
High	90	1.2	108

The identification of high and low yielding zones within the block indicates that remediation of the sodicity constraint (and/or associated poor drainage) in the low yielding zones has the potential to increase yield in these zones by approximately 50% (i.e., 68 tc/ha vs 108 tc/ha) (Table 5).

2.2 Case Study 2

Locality: Brightley

Farm: 3082

Scale: Within block

Block: 13-1

Lat/Long: -21.24064S 148.95302E

2.2.1 Soil type

Existing mapping (1:100 000 scale) (Holz and Shields, 1985):

Map unit #1530.

This map unit is labelled Victoria Plains (Black Vertosol), but is defined as an area likely to contain similar proportions of Victoria Plains, Calen (Brown/Grey Sodosol) and Brightley (Grey Vertosol) soils.

Draft disaggregated soils mapping (30m pixel resolution):

The disaggregated soils mapping suggests that the block (which comprises only a small section of the map unit) is dominated by Calen and Brightley soils (as per Case Study 1), with only a limited area of Victoria Plains soil.

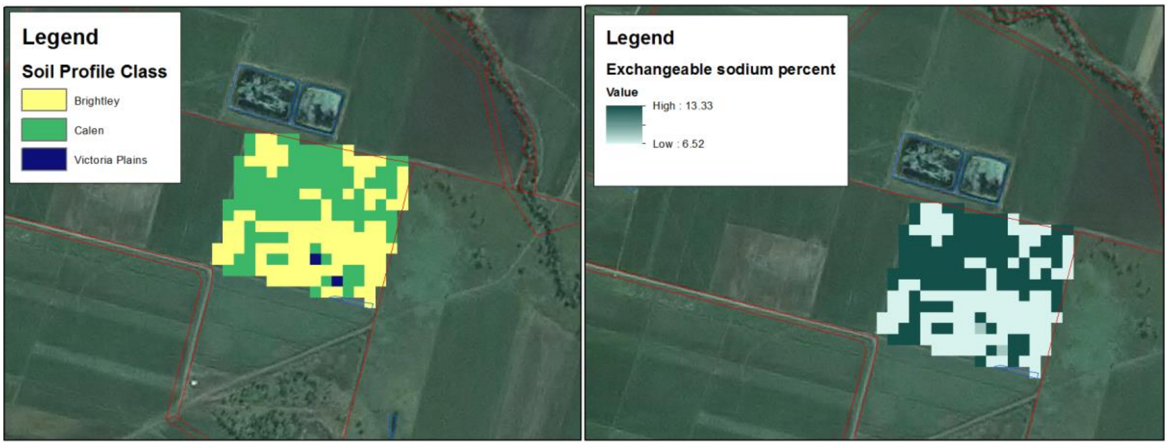


Figure 4 - (Left) Draft disaggregated soil mapping for Farm 3082, Block 13-1. (Right) Predicted exchangeable sodium (as percentage of total exchangeable cations), 60-100cm depth range.

2.2.2 Yield data

Table 6 - Cane variety, crop class and yield (tonnes cane/ha) as derived from mill consignment data (2001 to 2015)

Year	Variety	Crop class	Consignment yield (tc/ha)
2001		F	
2002	Q136	Plt	67
2003	Q136	1R	65
2004	Q136	2R	64
2005	Q136	3R	54
2006		F	
2007	Q196	Plt	83
2008	Q196	1R	81
2009	Q196	2R	81
2010	Q196	3R	75
2011		F	
2012	Q208	Plt	54
2013	Q208	1R	66
2014	Q208	2R	75
2015	Q208	3R	63

Table 7 - Block PUYP (tonnes cane/ha) as derived from mill consignment data

Crop class	Mean (tc/ha)	StdDev	Count	StdError	PUYP (2 StdErr) (tc/ha)	Max recorded yield (tc/ha)
Plt, 1R, 2R	71	9.84	9	3.28	77	83
R3	64	10.54	3	6.08	76	75

Table 8 - Block PUYP (tonnes cane/ha) as calculated from satellite data

Crop class	Mean (tc/ha)	StdDev	Count	StdError	PUYP (2 StdErr) (tc/ha)	Max estimated yield (tc/ha)
Plt, 1R, 2R	74	15.37	9	5.12	84	83

Whether estimated from consignment data or remotely sensed data, PUYP is close to the maximum recorded or estimated yields obtained over the thirteen year period.

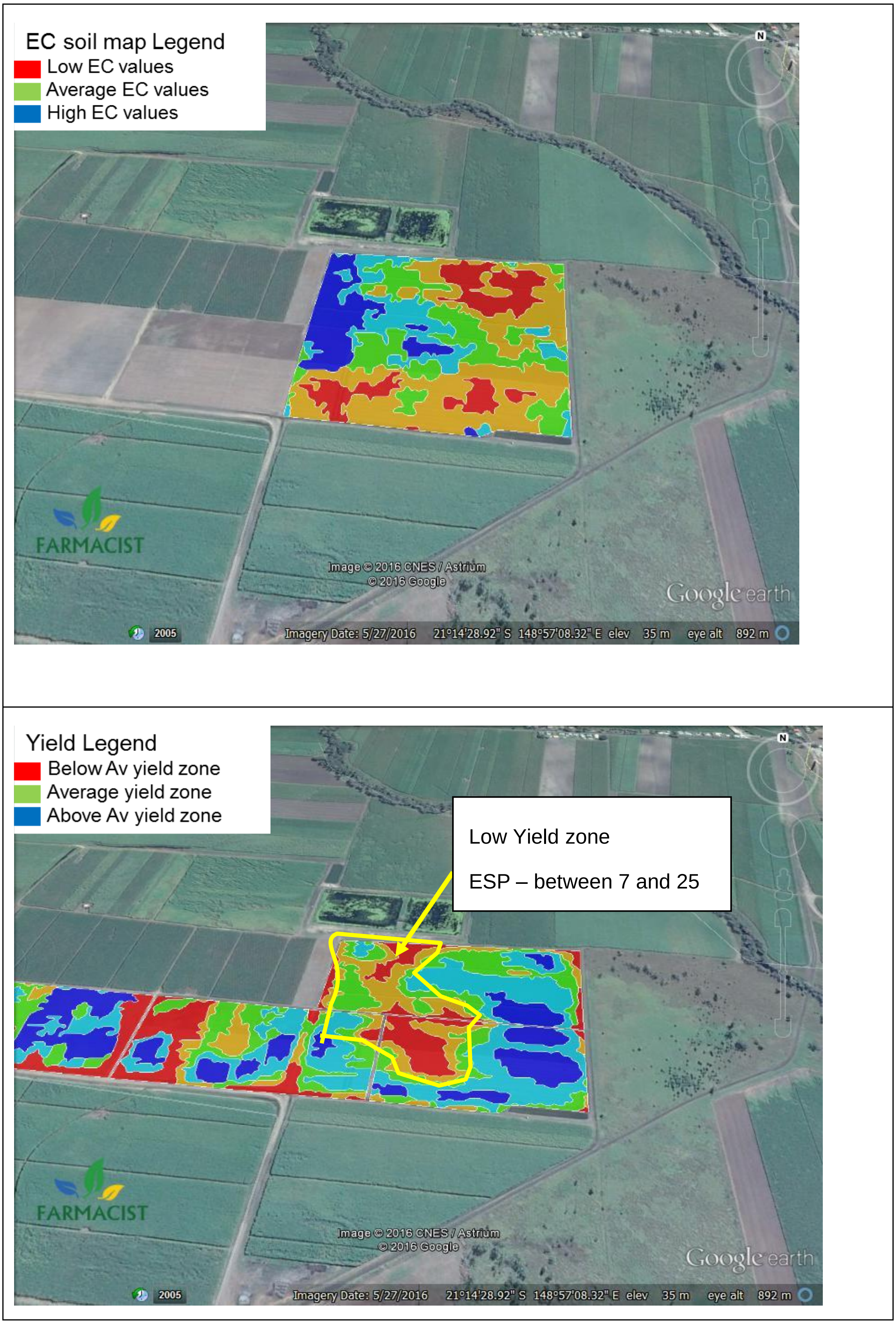


Figure 5 - EC_a (Apparent Electrical Conductivity) map obtained using an electro-magnetic induction instrument (EM38 model) (Top) and satellite yield mosaic map (Bottom) for Case Study Site 2

Analysis of soil samples collected in the low yield zone indicated relatively high ESP levels in both the shallow soil (0-25cm) and soil at depth (50-75cm) as shown in Table 9.

Table 9- Soil analysis results (low yield zone). Brown shading indicates less preferred values (?).

Lab Sample Id		21334795	21334796
Sample Depth (cm)		0 - 25	50 - 75
Sampling Date		28/11/2011	28/11/2011
Analyte / Assay	**Units**		
pH (1:5 Water)		6.9	8.3
pH $CaCl_2$		6.2	7.6
EC (1:5)		0.2	0.52
Chloride	mg/kg	200	340
Organic Carbon (OC)	%	0.75	
Nitrate Nitrogen (NO_3)	mg/kg	13	2.4
Phosphorus (Colwell)	mg/kg	52	
Phosphorus (BSES)	mg/kg	68	
PBI-Col		79	
Potassium (Amm-acet.)	meq/100g	0.27	0.3
Potassium	%	2	1.1
Potassium (Nitric K)	meq/100g	1.2	
Available Potassium	mg/kg	100	120
Sulphate Sulphur (MCP)	mg/kg	8.8	
Cation Exchange Capacity	meq/100g	13.3	26.2
Calcium (Amm-acet.)	meq/100g	6.5	8.5
Calcium %CEC	%	49	32
Magnesium (Amm-acet.)	meq/100g	5.5	13
Magnesium %CEC	%	41	50
Sodium (Amm-acet.)	meq/100g	1	4.4
Sodium % of Cations (ESP)	%	7.5	17

A strong relationship exists in mapping patterns of both yield values and deep (to 90 cm) EC_a values. Above-average yield zones are evident where EC_a values are low, and conversely low yield zones correspond with high EC_a mapping patterns. In this case, the yield constraint is identified as being high ESP and/or poor drainage within the western edge of the block as indicated in the yield map (Fig. 5). This section was primarily associated with the sodic Calen soil (Fig. 4).

Table 10 indicates that correction of the soil constraint(s) in low yielding zones has the potential to increase yield by approximately 50% (i.e., 67 tc/ha vs 101 tc/ha).

Table 10 - Zone PUYP (tonnes cane/ha) from satellite data (Block PUYP* Zone ratio)

Yield Zone	Block PUYP (tc/ha)	Zone Ratio	Zone PUYP (tc/ha)
Low	84	0.8	67
Average	84	1.00	84
High	84	1.2	101

2.2.3 Remediation costs: sub-surface ameliorants

To reduce the impact of sodicity on productivity within this block, the grower implemented a remediation program in 2016. The program involved the sub-surface application of soil ameliorants to a depth of 30 cm as indicated in Table 11. Note that the costs in Table 11 are application costs (labour and fuel) and product costs only, and do not include capital costs associated for application equipment.

Table 11 - Costs of remediating soil sodicity.

Remediation Component	Approximate cost (per ha)
Ground preparation • Deep Ripping • Trench opening • Post application trench closure • Speed tillage	$125
Application of mill mud @ 50 t/ha	$325
Application of mill ash within sodic sites @ 100t/ha	$450
Total cost	$900

If it is assumed that:

- the remediation of sodicity will increase the PUYP of the sodic zone from the current PUYP of 67 tc/ha to the average PUYP of 84 tc/ha;
- the net return from increased cane yield is $20/tc;

then it can be estimated that the remediation costs will be recouped over 3 years.

Whether the remediation costs are financially viable is the grower's decision. However, this example demonstrates the principle of using PUYP to identify low yielding areas and to consider the remediation/mitigation options as indicated in the Farm Nutrient Management Plan concept (Fig. 1).

2.3 Case Study 3

Locality: Homebush

Farm: 4202

Scale: within block

Block: 3-6

Lat/Long: -21.26376S 149.10024E

2.3.1 Soil type

Existing mapping (1:100 000 scale) (Holz and Shields, 1985):

Map unit #1967. This map unit is labelled Mirani, but is defined as an area likely to contain similar proportions of Mirani, Sandiford, and Calen soils.

Draft disaggregated soils mapping (30m pixel resolution):

The disaggregated soils mapping suggests that the block (which is a small section of the map unit) is almost entirely mapped as Calen. However, EM data (Fig. 7) highlight the variability that exists within soil profile class concepts.

Figure 6 - Draft disaggregated soil mapping for Farm 4202, block 3-6

2.3.2 Yield data

Table 12 - Cane variety, crop class and yield (tonnes cane/ha) as derived from mill consignment data (2001 to 2015)

Year	Variety	Crop class	Yield (tc/ha)
2001	Q135	Plt	69
2002	Q135	1R	63
2003	Q135	2R	45
2004		F	
2005	Q185	Plt	86
2006	Q185	1R	75
2007	Q185	2R	85
2008	Q185	3R	61
2009	Q185	4R	63
2010	Q185	5R	45
2011	Q183	Plt	standover

2012	Q183	1R	77
2013	Q183	2R	55
2014	Q183	3R	68
2015		F	

Table 13 - Block PUYP (tonnes cane/ha) as derived from mill consignment data

Crop class	Mean (tc/ha)	StdDev	Count	StdError	PUYP (2 StdErr) (tc/ha)	Max recorded yield (tc/ha)
Plt, 1R, 2R	69	14.4	8	5.09	80	86
3R, 4R, 5R	59	9.95	4	4.97	69	68

Table 14 - Block PUYP (tonnes cane/ha) as calculated from satellite data

Crop class	Mean (tc/ha)	StdDev	Count	StdError	PUYP (2 StdErr) (tc/ha)	Max estimated yield (tc/ha)
Plt, 1R, 2R	66	36.37	8	12.99	92	91

Whether estimated from consignment data or remotely sensed data, PUYP is similar by both methods and close to the maximum recorded or estimated yields obtained over the thirteen year period.

Figure 7 – EC_a map (Top) and the satellite yield mosaic maps for 2012 (wet year) (Middle) and 2013 (dry year) (Bottom) for Case Study Site 3

There is a reasonably strong relationship between EC_a and yield zones in several locations within the block, however the effect of the shallow water table (i.e., high EC_a zone) on yield is seasonally variable. A yield variation map generated for a particularly wet year (2012) highlights the dramatic loss of yield at the location of the perched water table (high EC_a area). Drier years also show a lower than average yield (2013) at this location, but the yield decline is not as evident when compared to the wetter years.

Table 15 - Zone PUYP (tonnes cane/ha) from satellite data in an above-average rainfall year (Block PUYP* Zone ratio)

Yield Zone	Block PUYP (tc/ha)	Zone Ratio	Zone PUYP (tc/ha)
Low (wet years)	92	0.70	64
Average	92	1.00	92
High	92	1.2	110

Table 16 - Zone PUYP (tonnes cane/ha) from satellite data in a drier rainfall year (Block PUYP* Zone ratio)

Yield Zone	Block PUYP (tc/ha)	Zone Ratio	Zone PUYP (tc/ha)
Low (average years)	92	0.90	83
Average	92	1.00	92
High	92	1.2	110

Partial remediation of this constraint is considered possible by placement of subsoil drainage ag-pipes, however this is a high cost option. Estimates of remediation vary from $8,000 to $20,000 per hectare depending on the extent of the problem, and a more practical option might be to use raised beds to mitigate the effects of wetter than normal seasons causing root zone saturation.

2.4 Case Study 4

Case Study 4 was located in Benholme on Farm 2219.

2.4.1 Block 9

Lat/Long: -21.15166S 148.790224E

Soil type:

Existing mapping (1:100 000 scale) (Holz and Shields, 1985):

Map unit #1037.

This unit is labelled Dunwold, but is defined as an area likely to contain similar proportions of Dunwold and Septimus soils.

Draft disaggregated soils mapping (30m pixel resolution):

Block 9 is mostly mapped as Dunwold (Fig 8., bottom part). It is located in a landscape position on the farm that is subject to extended periods of waterlogging.

Dunwold is a gleyed podzolic soil (Mottled, Grey Chromosol) described in Hardy (2003) as '…a loamy sand to sandy loam surface 0.20-0.45 m thick over a mottled (10-50%) grey to greyish-brown, acid to neutral, sodic (exchangeable sodium percentage of 6 to 14 in the first 0.10 m) light medium to medium clay subsoil with weak to moderate prismatic structure. The subsoil has low amounts of salinity (electrical conductivity levels 0.1 to 0.3 dSm^{-1}).'

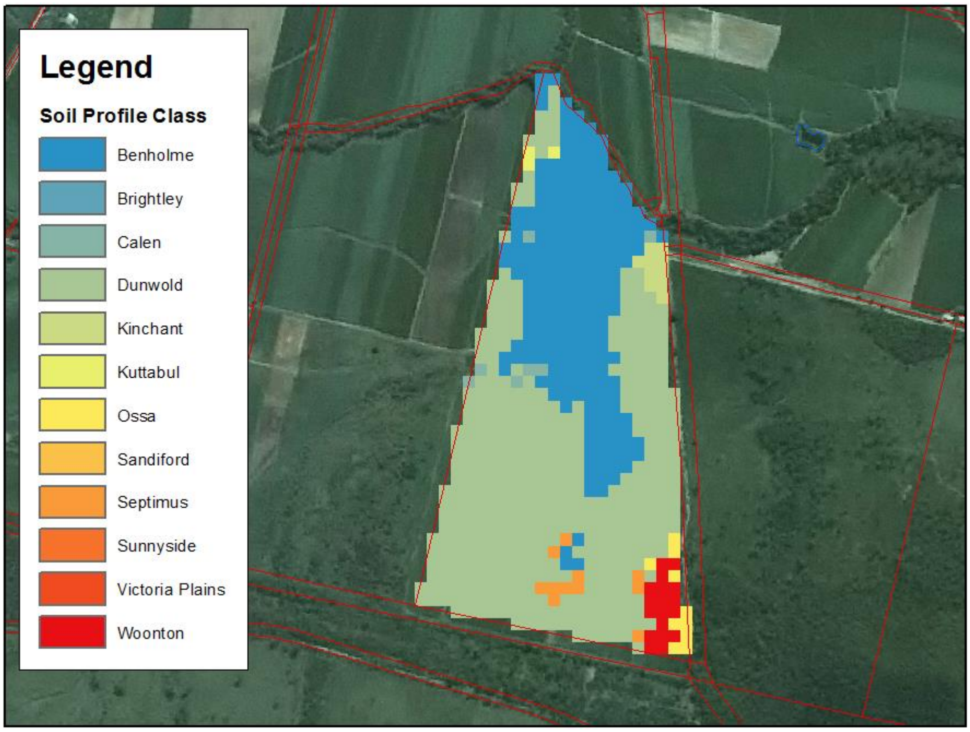


Figure 8 - Draft disaggregated soils mapping for Farm 2219, Blocks 4 and 9.

Table 17 – Block 9 cane variety, crop class and yield (tonnes cane/ha) as derived from mill consignment data (2001 to 2011)

Year	Variety	Crop class	Yield (tc/ha)
2001	Q124	2R	77
2002	Q124	3R	71
2003		F	
2004	Q138	Plt	85
2005	Q138	1R	80
2006	Q138	2R	52
2007	Q138	3R	70
2008	Q138	4R	74
2009	Q138	5R	85
2010	Q138	6R	80
2011	Q138	7R	
2012	Q138	8R	
2013	Q138	9R	
2014		F	
2015	Q242	Plt	60

Table 18- Block 9 – PUYP (tonnes cane/ha) as derived from mill consignment data

Crop class	Mean (tc/ha)	StdDev	Count	StdError	PUYP (2 StdErr) (tc/ha)	Max recorded yield (tc/ha)
Plt, R1, R2	71	14.10	5	6.30	83	85
R3-R6	76	6.36	5	2.85	82	85

Table 19 – Block 9 - PUYP (tonnes cane/ha) as calculated from satellite data

Crop class	Mean (tc/ha)	StdDev	Count	StdError	PUYP (2 StdErr) (tc/ha)	Max estimated yield (tc/ha)
Plt, R1, R2	69	17.00	5	7.60	85	80

Whether estimated from mill consignment data or remotely sensed data, PUYP is close to the maximum recorded or estimated yields obtained over the fourteen year period. PUYP estimated by both methods is very similar.

2.4.2 Block 4

Lat/Long: -21.14457S 148.79200E

Soil type:

Existing mapping (1:100 000 scale) (Holz and Shields, 1985):

Map unit #1056.

This map unit is labelled Benholme but is considered to contain equal proportions of Benholme, Victoria Plains, and Calen soils.

Draft disaggregated soils mapping (30m pixel resolution):

Block 4 is mostly mapped as Benholme (Fig. 8, top part of map).

Benholme is a Grey Vertosol, described as "…found in the backplain position of floodplains and in drainage depressions. This soil is deep with a dark grey topsoil which is 0.1 to 0.3 m thick with an acid to neutral pH. The subsoil is a mottled, grey, medium to heavy clay with mainly lenticular structure with an alkaline pH' (Hardy, 2003, p. 74).

This block is in a landscape position not subjected to the same degree of waterlogging as Block 9.

Table 20 - Block 4 cane variety, crop class and yield (tonnes cane/ha) as derived from mill consignment data (2001 to 2011)

Year	Variety	Crop class	Yield (tc/ha)
Year	Variety	Class	Yield
2001	Q124	6R	83
2002	Q136	Plt	92
2003	Q136	1R	83
2004	Q136	2R	81
2005	Q136	3R	75
2006		F	
2007	Q197	Plt	83
2008		1R	102
2009		2R	95
2010		3R	81
2011		4R	

Table 21 - Block 4 – PUYP (tonnes cane/ha) as derived from mill consignment data

Crop class	Mean (tc/ha)	StdDev	Count	StdError	PUYP (2 StdErr) (tc/ha)	Max recorded yield (tc/ha)
Plt, R1, R2	89	8.36	6	3.41	96	102
R3, R6	80	4.16	3	2.40	84	83

Table 22 - Block 4 - PUYP as calculated from satellite data

Crop class	Mean (tc/ha)	StdDev	Count	StdError	PUYP (2 StdErr) (tc/ha)	Max estimated yield (tc/ha)
Plt, 1R, 2R	94	23.58	6	9.63	113	110

Whether estimated from consignment data or remotely sensed data, PUYP is close to the maximum recorded or estimated yields obtained over the ten year period. The higher PUYP estimated from the satellite data is associated with higher variation of these yield estimates compared to the consignment data.

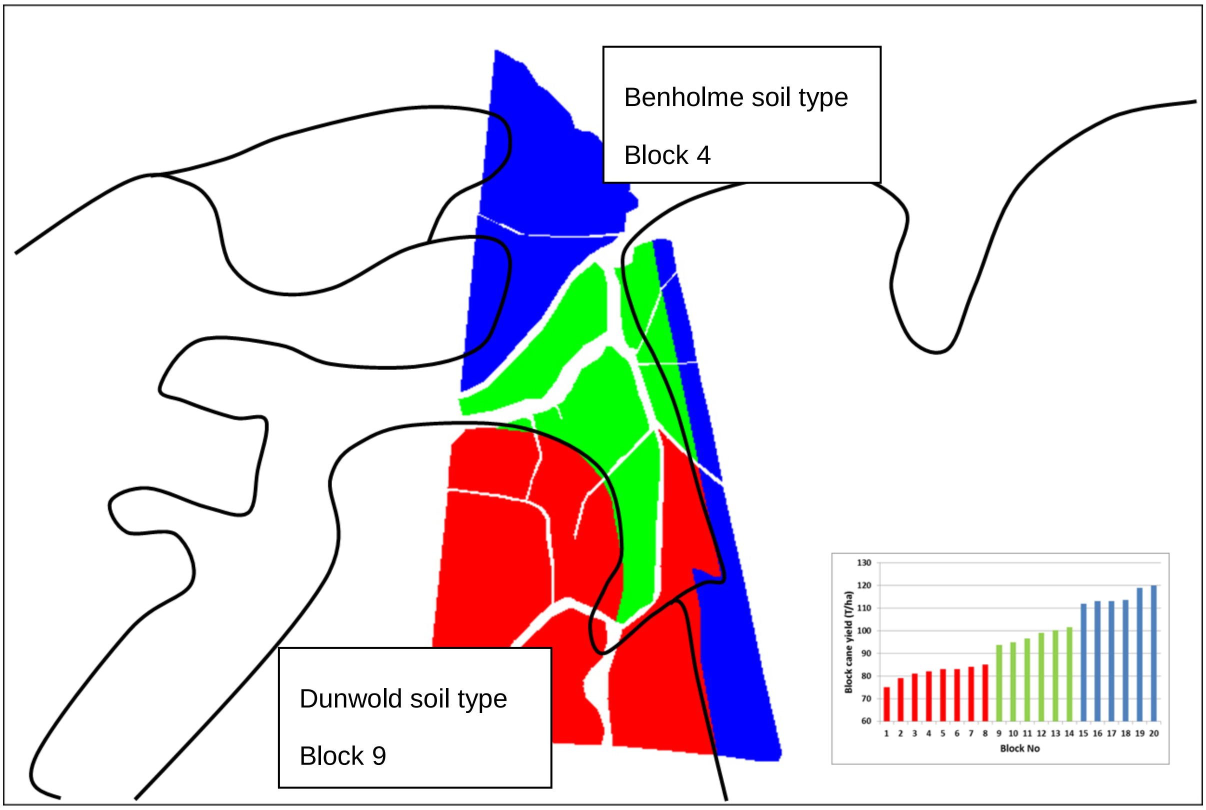


Figure 9 - Farm 2219 – PUYP (based on satellite data) of individual farm blocks (Blocks 4 and 9) with different soil types for Case Study 4

Figure 9 highlights the yield potential of blocks within Case Study 4. Block 9 is located in the southwest corner of the farm and is characterised as having Dunwold soil. Dunwold soils are considered highly erodible with low surface fertility and low to moderate PAWC. A significant area of Block 9 is often subjected to extended periods of waterlogging and therefore has a lower yield potential when compared to other parts of the farm.

Block 4 is located in the northern portion of the farm and is characterised as having Benholme soil. Benholme soils are considered to have a higher PAWC than Dunwold soils and are considered to be more productive. The landscape position of Block 4 is not normally subjected to waterlogging and is considered to have a higher yield potential.

The PUYP (Plt, R1, R2) of the Benholme soil is about 105 tc/ha (96-113 tc/ha depending on calculation method) whereas that of the Dunwold soil is about 84 tc/ha (83-85 tc/ha). These results indicate that the crop N requirement for maximum cane yield on the Dunwold soil would be lower than that required for the Benholme soil because of the lower intrinsic productivity of the Dunwold soil.

2.5 Comparison of crop N requirements using PUYP and DYP

The principle for calculating crop N requirements in the SIX EASY STEPS is based on deciding a target yield (tc/ha) and then multiplying the target yield by the 1.4/1 multiplier (1 kg applied N/tc to 100 tc/ha , then 1 kg applied N/tc thereafter) to derive the crop N requirement. The current 'target yield' used in SIX EASY STEPS is the District Yield Potential (DYP), but there are provisions in the SIX EASY STEPS guidelines to use appropriate 'target yields' based on the past performance of a parcel of land, be that within-block or multiple blocks.

Case Study 4 demonstrates the effect of soil type/landscape position on productivity. While PUYP calculated from consignment data for early crop classes (plant, R1, R2) grown on the Benholme soil was 96 tonnes cane/ha, the corresponding PUYP for the Dunwold soil was only 83 tonnes cane/ha. If the target yield for both soil types was the district DYP of 120 tonnes cane/ha, then the crop N requirement would be calculated as 160 kg N/ha for both soils. However, if the PUYP of the lower yielding Dunwold soil is set at 83 tonnes cane/ha, then the crop N requirement for this target yield using the SIX EASY STEPS N 1.4/1 multiplier gives a crop N requirement of 116 kg N/ha, considerably less than the DYP crop N requirement of 160 kg N/ha.

It is known that the Dunwold soil is often seasonally waterlogged because of its intrinsic low internal permeability and generally low-lying position in the landscape. These conditions are conducive to fertiliser N loss by denitrification and perhaps runoff, and the best management strategies for reducing these losses is to use raised beds (to maintain an aerobic root zone), sub-surface N application, and blends of urea with currently available enhanced efficiency fertilisers such as those with nitrification inhibitors or controlled release via polymer coatings. The former products aim to maintain fertiliser N in the ammonium-N form for as long as possible, thereby reducing the risk of denitrification, while the latter products aim to synchronise fertiliser N release with crop demand. These strategies maximise the potential for fertiliser N uptake by the crop. Nitrogen applied as straight urea is vulnerable to loss by leaching, runoff or denitrification, depending on soil type, position in the landscape and season. Therefore, adjusting fertiliser N input based on PUYP must go hand-in-hand with management strategies to minimise fertiliser N loss.

Table 23- Comparison of crop N requirements and fertiliser costs for plant, R1, R2 crops based on DYP and PUYP (mill consignment data) for the Dunwold soil at the Benholme Case Study 4 site. No discounts for other sources of N have been made to N requirements. Fertiliser costs are based on urea @ $490/t and ENTEC-urea @ $645/t.

Target yield description	Target yield (tc/ha)	Crop N requirement (kg N/ha)	N Use Efficiency (kg applied N/tc)	N fertiliser cost ($/ha)	
				Urea	ENTEC-urea
DYP	120	160	1.9	$170.52	$224.46
PUYP	83	116	1.4	$123.84	$163.01

As an example of the cost comparison between using urea and a urea product with nitrification inhibitor (ENTEC-urea), Table 23 shows that applying the PUYP crop N requirement entirely as ENTEC-urea is less costly than applying urea at the DYP rate. Assuming that the PUYP is achieved, the NUE of urea applied to the Dunwold soil at the DYP N rate is 1.9 kg applied N/tonne cane (i.e., 160/83) compared to the NUE of ENTEC which is 1.4 kg applied N/tonne cane (i.e., 116/83). It is apparent that besides saving fertiliser costs, NUE has increased and losses to the environment via greenhouse gases and/or in runoff/drainage would be reduced at the lower N rate.

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