SRDC Grower Group Innovation Project
Final Report

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Project title: The Next Step for Precision Agriculture

Group name: Homebush Innovative Grower group

Contact person: *Tony Bugeja*

Due date for report:

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Body of Report

Executive Summary:

(An overview of the aim, conduct, key results and learnings from the project. Maximum 500 words)

Growers in the Homebush Innovative Growers Group are well aware of the within-paddock variability that occurs within paddocks. The adoption of electrical conductivity (EC) soil mapping technology verified the patterns of contrasting soil properties and satellite yield estimation maps produced by Mackay Sugar indicated considerable variability in sugarcane paddocks across the central cane growing region. The GGIP project titled “The Next Step for Precision Agriculture” provided an opportunity for the group to gain a better understanding of the interaction of variables that contribute to spatial variability within a paddock.

Following the EC soil mapping of the study site, ground-truthing of EC soil mapping patterns indicated the presence of four distinct soil groups in a transect across the paddock. A comprehensive trial plan was developed incorporating the planting of replicated sugarcane plots in each of the four spatially defined soil groups to determine yield differentiation across the soil groups. The replicates for each soil group were split between conventional farming (CF) practices and a traffic free (TF) status to determine the affects of compaction on yield. To develop a better understanding of the agronomic variables that influence yield a number of measurements were undertaken in designated vegetation free zones established at the end of each TF plot across the soil groups, namely:

- Chemical and particle size analysis to a depth of one metre (topsoil, upper subsurface and lower subsurface)
- Bulk density, water infiltration and soil resistivity from the apex of the hill up and the inter-row zone
- Nematode and Pachymetra monitoring in a crop and vegetation free environments to determine persistence and population dynamics over plant and ratoon phases

Bulk density sampling and soil resistivity measurements increased bulk density by 14% after only two traffic passes. The lighter textured soils having a greater propensity for compaction. The group are considering soil specific tillage programs based on EC mapping patterns and soil physical properties. Monitoring nematode and Pachymetra populations verified the need to conserve organic matter and select nematode resistant fallow crops.

Particle size and chemical analysis results confirmed the ability of EC soil mapping to spatially differentiate zones of contrasting soil properties. Ground-truthing of a mosaiced EC mapping patterns of the wider 82 hectare sugarcane enterprise validated the ability of EC soil mapping to accurately define variability within-paddocks and across farms. This exercise revealed the inadequacy of current 1:100,000 coarse scale soil surveys to support precision agriculture (PA) in sugarcane as the farm had been mapped as one soil unit.

There was no significant difference in yield and stalk counts across the soil groups in the plant cane phase. Unfortunately cyclonic conditions severely impacted on the integrity of the yield data in the ratoon phase. However, ground-truthing of yield patterns from processed satellite imagery provided invaluable information which clearly demonstrated the relationships and interaction between soil properties elevation/ topography and yield. A number of possible PA management practices emerged from this component of the project and provided a potential pathway for managing within paddock yield variability and the geographic information system (GIS) layers that will underpin PA in the future.

Background:

(Why did you need to do this project?)

Members of the Homebush Innovative Growers Group have been involved with a number of Precision Agricultural (PA) type activities to enhance the economical and environmental sustainability of their sugarcane production systems. These activities include variable rate planting trials, controlled traffic farming with GPS, zonal tillage and EC soil mapping. The most accurate soil survey maps available to sugarcane producers in the Central Region are at a scale of 1:100,000. Growers within the group were quick to realise that the variability of soils that occur within many paddocks were not evident in the digital format of the 1:100,000 soil survey mapping patterns. The within paddock variability of soil properties was confirmed by patterns evident from EC soil mapping surveys and similarly many paddocks displayed large variability in yield confirmed by annual satellite yield estimation patterns available through Mackay Sugar.

Identifying and managing within-paddock spatial variability is regarded as a key component of PA. The project was initiated by the group to develop a better understanding of the complex interaction of variables that influence within paddock yield variability. The results generated from this project would enable members of the group and the wider cane growing community to develop better practical management strategies to reduce yield variability or modify inputs based on access to key spatial information. Progressing PA in sugarcane provides a pathway for maximising profitability and a means to enhance the quality of water leaving sugarcane paddocks.

Aims:

(Include the Aim and the expected benefits that were listed in Section 2 of your original Application)

Currently PA in sugarcane centres around controlled traffic, zonal tillage and aspirations for the variable rate application of nutrients. The fundamental aims of this project are to comprehensively investigate a range of agronomic variables that influence yield and include:

- The physical and chemical properties of soils with contrasting attributes as defined by EC mapping
- The persistence of nematode and pachymetra populations in soil with contrasting soil properties both in a crop and vegetation free environment
- The influence of compaction on yield in zones with contrasting soil properties
- Determination of within paddock yield variability through hand harvesting of plots in zones designated by EC mapping patterns

The results of this study would provide a pathway for the site specific management of defined within paddock yield zones and better understanding of the interaction of agronomic variables that influence yield and how they may be better managed. Pivotal to the progression of variable rate application of nutrients is: 1) the spatial identification of zones with contrasting soil properties. 2) A thorough understanding of the chemical and physical properties of the soils within the zones.3) Determination of the yield potential of defined zones. This project seeks to investigate these factors and to integrate the findings with aligned projects to advance the adoption of PA in sugarcane production systems

Methodology:

(How was the project conducted?)

A sugarcane paddock (location, 720646.6204/ 7649771.4294 MGA 94 zone 55) belonging to Tony and John Bugeja had been selected as a study site by the SRDC funded research project BPS001 titled *"Identifying management zones within cane paddocks: an essential foundation for precision sugarcane agriculture*. To reduce duplication of activities and resources the same paddock was selected to conduct the GGIP trial. The 10.98 hectare paddock was EC mapped with a Veris 3100 EC soil mapping unit at 10 metre swathe widths on the 17 June 2008. The fallow paddock had been cultivated on a number of occasions to reduce the residual compaction from the previous crop cycle and for weed control. The spatial data sets were processed through Manifold® GIS software to produce 'five zone' kriged interpolated surface layers for the shallow (0-30 cm) EC dataset as well as the deep (0-90 cm) EC values. Ground-truthed geo referenced borehole sites of the deep EC layer mapping patterns validated the presence of four distinct soil groups with contrasting soil properties along a 360 metre transect across the paddock (Figure1). Particle size and chemical analysis samples were extracted from these soil group representative sites in the topsoil zone (0-25 cm), upper subsurface (40-60 cm) and lower subsurface (75-100 cm). The samples were analysed by Incitec/Pivot laboratories. Moisture samples were extracted at 10 cm intervals to a depth of 100 cm.

A trial design was developed and based on the EC mapping patterns from the Veris soil mapping survey and the four distinct soil groups positioned along a 360 metre transect. The trial layout incorporates the planting of four replicate plots positioned within the designated EC mapping patterns for each of the soil groups. Two of the replicates were designated as traffic free (TF) apart from the initial planting operation with the balance of the replicates being subject to conventional farming (CF) traffic regimes. The trial design incorporates guard rows on either side of the twelve metre measurement rows with provision for haul-out traffic laneways for the machine harvesting of cane in the conventional component of the trial (Figure2). Ten metre measurement rows were marked out from the centre of each 12 metre plot for all replicates for each of the four soil groups along the trial transect. All soil physical and chemical measurements were extracted from permanent zones (5 x 1.8 metre) located at the eastern ends of the TF plots for each of the four referenced soil groups. The trial was planted to Q208 on the 29 August 2008 using a Dickey John controlled wide chute planter at a planting rate of 5.18 tonnes per hectare. Weed control in the vegetation-free areas of the trial was achieved with the application of glyphosate through a boom spray using the haul-out laneways to ensure the integrity of the TF plots. Weeds were controlled in the inter space between measurement and guard rows by hand chipping and strategic application of glyphosate using back-pack spray units.

Stalk counts were conducted on replicate measurement rows for both TF and CF treatments at 111, 196, 283, 312 and 334 days after planting (DAP) during the plant cane phase of the trial and at 209, 328 and 412 days after harvest (DAH) during the first ratoon phase of the trial

To determine the persistence of Pachymetra and nematode populations in a vegetation free environment and the dynamics of populations in different soil texture classes sampling was carried out in mid February 2009 during the plant cane phase of the project. Samples were extracted from the vegetation-free measurement zones as well as well as the traffic-free sugarcane plots across the four soil groups of the trial. On the 12 April 2010 (257 days after harvesting of plant cane) the Pachymetra and nematode sampling regime was repeated during the first ratoon phase of the project. A soil corer was used to extract the pachymetra and nematode soil samples to a depth of 20 cm with an average of 20 cores per composite plot sample. Pachymetra analysis and nematode counts were conducted by the BSES in the Tully laboratories

Bulk density sampling, water infiltration rates and soil resistivity measurements were taken over a three day period in the absence of rain to ensure that relative comparisons could be made across the four soil groups. Sampling was concentrated on the apex of the hill-up and inter-row zones and confined to the replicated TF plots in the four soil groups. Traffic movement in the TF plots had been restricted to a total of two tractor passes (planting and hilling-up operations). To ensure the integrity of the data sampling was undertaken in the designated 5 x 1.8 metre vegetation free zones established at the ends of the TF plots across the four soil groups.
Bulk density sampling to a depth of 10 cm was obtained from the centre of the hill-up and adjacent inter row zones from the replicate traffic-free soil groups. Sampling was replicated three times for each TF plot. Moisture percentages were calculated by measuring the differences in weight before and after the oven drying of the bulk density samples (at 105º C). Water infiltration rates were calculated from infiltration measurements using 15cm diameter aluminium rings driven 7.5 cm into the soil. The time is recorded for the time it takes for 445 ml (equivalent to 25 mm of rainfall) of added water to infiltrate the soil (Figure 5). Water infiltration rates on the hill-up were calculated from the sequential addition of two 445 ml of water to the infiltration rings (equivalent to 50 mm of rainfall). Infiltration calculations for corresponding inter-row measurements were confined to a single addition of 445 ml of water as the infiltration rates generally exceeded a 30 minute timeframe. Infiltration measurements were replicated three times for the hill-up zone and inter-row z0nes for each TF plot across the four soil groups

Soil resistivity was measured using a dynamic cone penetrometer by recording the amount of blows to penetrate to a depth of 48 cm. Resistivity measurements were replicated four times (hill-up and inter-row) for each TF plot across the four soil groups.

The measurement rows were hand harvested and weighed in all replicated plots for each soil group along the transect. In the plant cane phase of the project buffer rows were also hand harvested in all TF plots to ensure the traffic free status was upheld. The total biomass of each measurement row was weighed on a trailer mounted weigh platform. A sub sample of 20 stalks were randomly selected and the vegetative ‘tops’ removed between the 5 and 6 visible dewlap. The stripped stalks for each plot were weighed and recorded. The excised tops were also weighed and recorded. This process emulates the action of the harvester topper and enables the calculation of the ‘percent millable stalk’ for each plot. Six stalks were randomly selected from the ‘20 stalk’ sub samples for each and submitted to the BSES for CCS determination.

The 10.98 hectare trial block is one of six blocks of the Bugeja’s Rosella farm. In the1:100,000 soil survey, the whole farm was mapped as a single mapping unit (Sandiford).The 82 hectare farm has been progressively EC mapped during the fallow phase since 2003. A component of the project was to ground-truth the EC mapping patterns of the mosaiced composite soil EC map of the whole farm to determine the ability of EC mapping to accurately define areas of contrasting soil properties. Based on the mapping patterns evident in the mosaiced EC soil map, forty sites geo-referenced sites were selected for pattern validation. Soil cores (to a depth of 1 metre) were collected and stored from selected sites across the 82 hectare farming enterprise.

A high resolution satellite image (Ikonos) was captured over the trial site on the 19 June 2010. The imagery was processed through Envi® software to produce a normalised difference vegetation index (NDVI) yield map. Based on the NDVI yield patterns, 14 referenced sites were selected for hand harvesting and calibration of NDVI values. Ground-truthing of NDVI yield patterns commenced on the 17 September 2010. Following site location with a Garmin hand-held GPS, 5 metres of cane row was marked out and stalks counted and recorded. The referenced sites were hand harvested and weighed on a trailer mounted weigh platform. The total biomass (including the ‘tops’) from the 5 metres of cane row was recorded as the topper of the harvester was not engaged due to crop lodging. The data was processed through Manifold ® GIS software in order to allocate NDVI values to referenced yield data from the selected hand harvest sites.

Results and Outputs:

(What results were produced by the Project? The results should include data collected, articles or reports written, events held and anything else you see as relevant to the industry. Relevant files including photographs should be provided on a CD.)

Fallow/plant cane phase of project

During the fallow phase of the crop cycle the 10.98 hectare paddock was EC mapped with a Veris 3100 EC soil mapping unit at 10 metre swathe widths on the 17 June 2008. Following processing, four referenced sites were selected for ground-truthing based on soil mapping patterns evident in the kriged soil surface layer. Soil cores (1 metre profiles) extracted from the four EC mapping patterns validated the capacity of the Veris 3100 EC soil mapping unit to accurately define zones of contrasting soil properties. For trial purposes the four defined soil zones were defined as soil groups A, B, C and D from west to east across the transect (Figure 1)

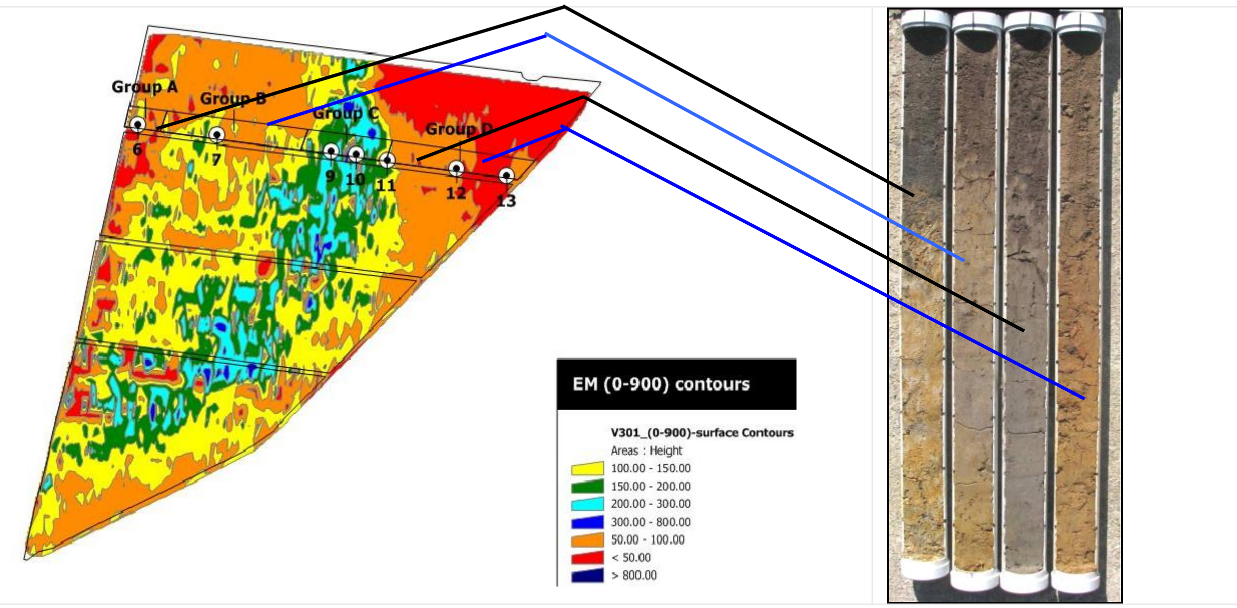

Figure.1- Deep EC mapping patterns with associated soil profiles (to a depth of 1 m) representing designated soil groups from the 360 metre trial transect

Group A and D soils produced relatively lower EC values (red and orange coded EC values) relating to the lighter textured soil profiles while group C soils produced higher EC values (green and blue coded values) with higher clay levels through the profile. The trial cane plots were planted within the boundaries of the soil group zones depicted on the EC soil mapping layer (Figure 2)

Figure. 2- Established trial showing designated laneways for harvesting haul-out passage and soil group locations derived from EC mapping patterns

The plant cane trial plots were hand harvested on the 31 July 2009. Statistically there was no significant difference in yield between the four soil groups or between the traffic free replicates and conventional traffic replicates (Table 1) However, there were visible differences in the flowering status of the crop between the A and D soil groups. The flowering in the A, B, and C cane plots were well advanced as opposed to the flowering in the relatively well drained D group zone where flowering had only recently commenced. Tony Bugeja confirmed that the plots in the D group zone were 3-4 weeks off harvesting. This is substantiated by the significant difference in millable stalk percent in the D group plots which were still actively growing and accumulating biomass. The sugarcane variety Q208 is reasonably well adapted to growing in a variety of soil types

Table 1- Average yield and associated data from the hand harvesting of plots across soil groups in the trial transect

Soil Group	Stalks/m²	% millable stalks	Cane tonnes/ha	CCS	Sugar tonnes/ha
A	7.9	90.4	92.9	17.08	15.87
B	8.5	89.8	99.5	17.52	17.43
C	8	88.6	92.2	17.33	15.98
D	8	*85.1	98.5	16.9	16.64
Significance	*ns*	*P 0.025*	*ns*	*ns*	*ns*

Stalk counts were conducted on replicate measurement rows for both TF and CF treatments at 111, 196, 283, 312 and 334 days after planting (DAP). The stalk counting regime was influenced by paddock conditions as paddock entry under wet conditions would compromise the compaction status of the TF replicates. There was no significant difference in average stalk counts across the soil groups or between the TF and CF plots (Table2). Stalk numbers reduced over time in the plant cane plots through natural shedding of stalks (Figure 3). It was observed that the trial plots were unnaturally exposed to wind which funnelled through the open nature of the plots across the trial transect. This channelling of wind resulted in additional lodging and stalk loss in the exposed plots and a possible reduction in the yield potential of the replicate plots.

Table 2- Averaged stalks/m² for traffic free and conventional farming systems by soil group

Soil Group	Treatment	111 DAP	196 DAP	238 DAP	312 DAP	334 DAP
A	Traffic free	9.7	9.1	8.7	8.6	8.3
A	Conventional	9.4	8.7	8.1	7.7	7.7
Group ave		**9.6**	**8.9**	**8.4**	**8.2**	**8.0**
B	Traffic free	9.1	8.8	8.6	8.4	8.2
B	Conventional	10	9.3	9.1	8.9	8.8
Group ave		**9.9**	**9.1**	**8.9**	**8.7**	**8.5**
C	Traffic free	8.5	8.3	8.2	8.0	8.0
C	Conventional	8.7	8.3	8.0	7.9	7.9
Group ave		**8.6**	**8.3**	**8.1**	**8.0**	**8.0**
D	Traffic free	8.5	8.2	8.1	8.0	7.9
D	Conventional	8.7	8.0	7.9	7.9	7.8
Group ave		**8.6**	**8.1**	**8.0**	**8.0**	**7.9**

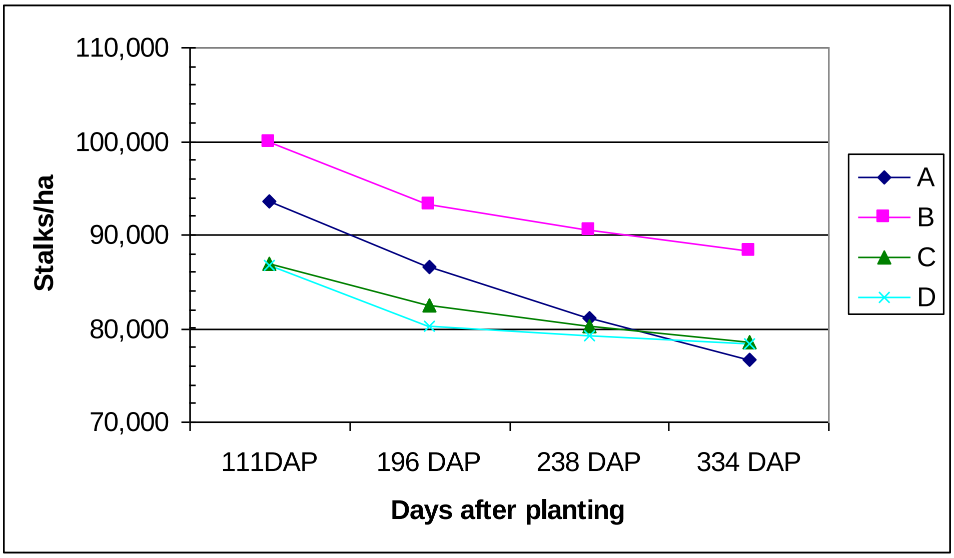

Figure 3- Dynamics of averaged stalk populations for the four soil groups over time

Pachymetra and nematodes sampling was carried out mid February 2009. Sampling was confined to the designated vegetation free measurement zones (1.8 x 5 metres) established at the end of TF plots (Figure 4) and to the TF cane plots themselves. The objective of this sampling regime was to 1) Determine the persistence of parasitic nematodes and pachymetra in a vegetation/host free environment across soil groups with known physical properties and 2) Monitor the dynamics of pachymetra and nematode populations (parasitic and free living) in a corresponding sugarcane crop environment.

Figure 4- : Designated measurement zones positioned at end of traffic free cane plots for the measurement of relative physical and chemical soil properties and to determine persistence of soil borne diseases in a vegetation free environment

Over a 14 month period parasitic nematodes numbers had reduced significantly in a vegetation/host free environment. However, a nucleus population still remained active in a comparative bare fallow situation irrespective of physical soil properties. In contrast, a 14 month bare fallow situation had little affect on average pachymetra spore numbers across the soil groups. There appears to be little population differentiation between crop and bare fallow environments for three classes of free living nematodes (Bacterivore, Fungivore and Dorylamids) while Monochid populations appear to decline over time in a vegetation free environment and across all soil groups (Table 3). In the crop situation the ratio of free living nematodes to parasitic nematodes varied between the 4 soil groups:
Group A- 1:0.93
Group B- 1:1.64
Group C- 1:1.45
Group D- 1:1.14

This preliminary study indicates that the lighter textured soils indicated by EC mapping (Group A and D) have a better ratio of free living to parasitic nematodes than the heavier textured poorly drained soils. Free living nematodes are able to parasitise parasitic nematodes and play an important role in recycling nutrients.

A weed/vegetation free status was maintained in the designated TF measurement zones with a routine glyphosate herbicide program

Table 3-Average Pachymetra, parasitic and free living nematode populations in a crop and 14 month vegetation free environment for four soil groups

Soil Group	Average parasitic nematodes (per 200ml soil)		Average pachymetra (spores/kg of soil)	
	In crop (cane plots)	Vegetation free (14 months)	In crop (cane plots)	Vegetation free (14 months)
A	468	17	4024	1857
B	1604	36	2813	4703
C	2021	55	6305	9120
D	1092	16	4635	4599

Free living nematodes

Soil Group	Bacterivore (per 200 ml of soil)		Fungivore (per 200 ml of soil)		Dorylamids (per 200 ml of soil)		Monochids (per 200 ml of soil)	
	Crop	Vegetation free (14 months)	Crop	Vegetation free (14 months)	Crop	Vegetation free (14 months)	Crop	Vegetation free (14 months)
A	145	175	101	63	89	34	168	40
B	317	357	225	225	190	178	245	24
C	965	695	286	214	23	68	114	55
D	497	359	432	404	22	59	11	12

Particle size and chemical samples were collected for analysis at the four geo-referenced sites representing the soil groups identified by soil EC mapping patterns (Table 4).The samples were collected from the topsoil (0-25 cm) upper subsurface (40-60 cm) and lower subsurface (75-100 cm). The results of the analysis validate the variability of soil texture and nutrient properties that can occur within a paddock and the role that EC mapping technology provides to spatially define zones of contrasting properties within a landscape.

Table 4- Chemical and soil texture analyses at the surface, upper subsurface and lower subsurface of four EC soil groups and the average yield from representative soil group plots

Soil Group	Nitrate N (mg/kg)	Calcium (mg/kg)	Potassium (mg/kg)	Phos (BSES) (mg/kg)	Sodium (% cats)	CEC (meq/100g)	OC (%)	Sand Coarse + Fine (%)	Silt + Clay (%)	Yield (tonne/ha)
Topsoil (0 – 25 cm)										
A	16	1.7	0.22	51	1.9	3.36	0.69	76.2	23.8	93
B	13	3.4	0.16	24	2.5	5.26	0.84	59.9	40.1	100
C	18	3.9	0.20	21	2	7.7	1.1	55	45	92
D	9	2.3	0.14	26	1.1	3.81	0.81	69.4	30.6	99
Upper subsurface (45 – 60 cm)										
A	2.9	1.4	0.09		2.5	2.6		75.6	24.4	93
B	3.3	8.5	0.19		6.7	16.5		44.4	55.6	100
C	6	13	0.29		4.5	22.2		26	74	92
D	4.7	6	0.14		2.7	9.7		38.7	61.3	99
Lower subsurface (75 – 100 cm)										
A	1	5.5	0.15		5.3	9.13		55.6	44.4	93
B	1	5	0.13		12	9.73		71.9	28.1	100
C	2	16	0.34		7	29.4		20	80	92
D	1	6.5	0.17		2.8	11.4		47.5	52.5	99

**No significant difference in the averaged hand harvested yield data from the soil groups*

However, no conclusions can be drawn from the influence of soil nutrient data and soil texture information on final yield as there was no significant yield differences across the four soil groups.

After establishment of the trial bulk density sampling, water infiltration rates and soil resistivity measurements were undertaken to determine relative differences in soil physical properties across the four soil groups (Table 5). Sampling was confined to the replicated traffic free-zones in the four soil groups on the hill-up and the inter-row zones which had only been subjected to two machinery passes (planting and hill-up). All sampling was undertaken in the designated 5 x 1.8 metre zones established at the ends of the traffic-free plots across the four soil groups (Figure 5)

Table 5- Average bulk density, water infiltration rates and moisture percentages in the hill-up and adjacent inter-row pertaining to the four soil groups

Soil groups	Bulk density (to 10 cm)			Water infiltration rate (mm/minute)		Moisture % (10 cm)	
	Hill-up	Inter-row	% increase	Hill-up (50mm rain equivalent)	Inter-row (25 mm rain equivalent)	Hill-up	Inter-row
A	1.49	1.65	9.7	1.1	<0.8	16.7	15.5
B	1.28	1.51	15.2	1.05	<0.8	20.3	17.8
C	1.21	1.33	9.0	2.28	1.3	23.3	18.9
D	1.27	1.61	21.1	3.03	<0.8	16	15.1
Average	1.31	1.53	14.3	1.87	< 1.00	19.08	16.83

There was an average of a 14.3 % increase in soil bulk density with the passage of two machinery movements across the soil groups and water infiltration rates were nearly halved. The soil groups with the highest sand content in the topsoil had the highest bulk density readings following two machinery passes (groups A and D with post traffic bulk density values of 1.65 and 1.61 respectively). The relatively low moisture percentage values for both hill-up and inter-row zones for soil groups A and B indicate that paddock traffic should be kept to a minimum in the sandier soil types. Having all machinery on GPS with matching row spacing is likely to enhance the yield potential of the lighter textured soils especially in low rainfall seasons. The A and D soil groups have relatively lower organic carbon percentages (see Table 4) which indicate that mechanical tillage on these lighter soil types should be reduced as much as possible to conserve organic matter and reduce compaction. These management strategies will enhance the yield potential of the lighter textured soils over time. Members of the group are utilising this information to develop strategic zonal tillage management plans which take into account the variability and textural properties of soils within paddocks.

The project study site paddock resides within a larger 82 hectare sugarcane producing enterprise located on the Rosella/Homebush road, 10.7 kilometres south west of the city of Mackay. The Rosella farm has been systematically EC mapped during the fallow phase since 2003. The only soil map available in the central sugarcane growing region is at a scale of 1:100,000. In this survey the Rosella farm is mapped as a single soil unit (Sandiford). However, the composite mosaiced EC map of the Rosella farm indicated patterns of soil variability across all paddocks and the satellite yield estimation maps (Mackay Sugar) revealed considerable within paddock yield variability across the Rosella farm. Forty geo-referenced borehole sites were selected on the basis of the mapping patterns evident in the composite EC soils map of the Rosella. Soil cores extracted from the pre-selected geo-referenced sites confirmed the variability of soil properties that occur on a whole farm basis (Figure 5). The ground-truthing regime validated the ability of EC mapping technology to spatially define zones with contrasting soil texture properties with lower EC values generally relating to the lighter textured soils and the higher EC readings relating to the heavier textured soils.

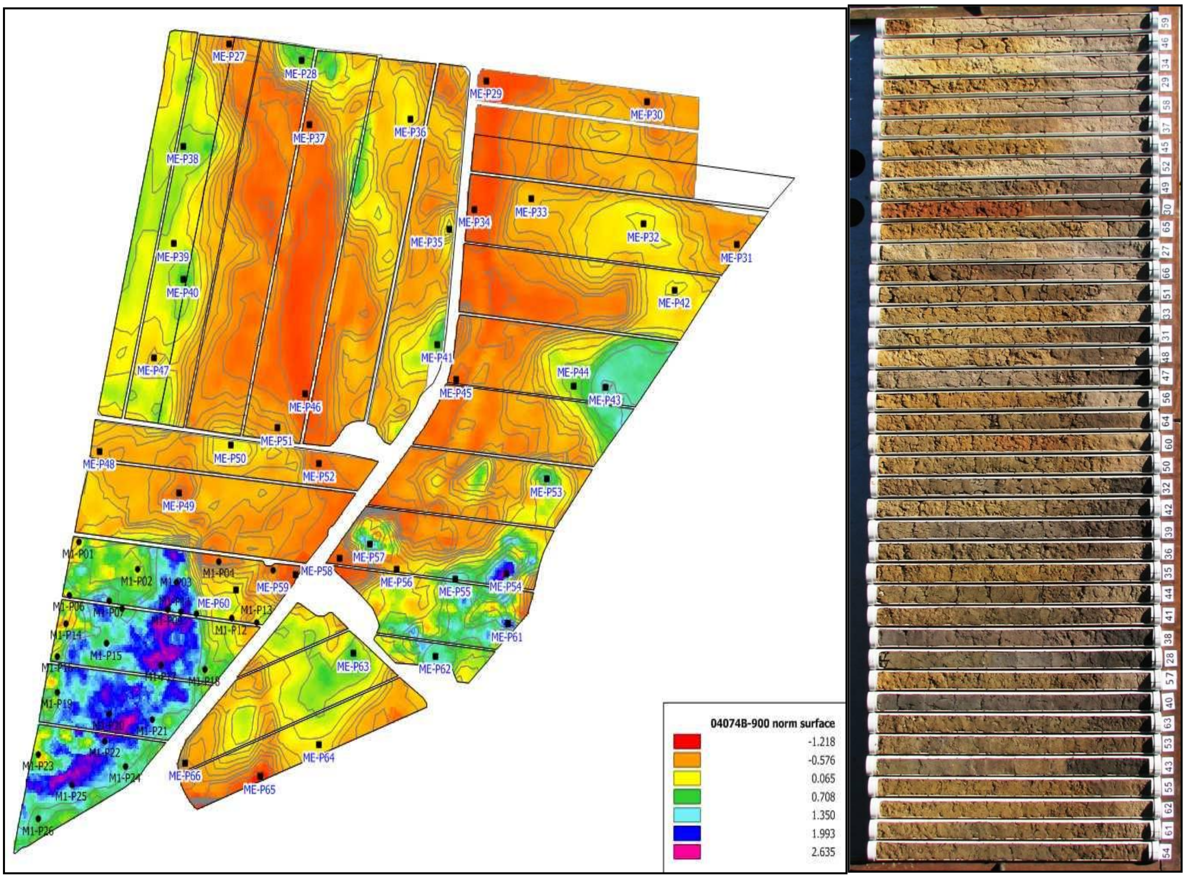

Figure 5- Composite soil EC map of the 82 hectare Rosella farm and the 40 soil cores extracted from pre-selected geo-referenced validation sites based on deep EC mapping patterns

The whole farm validation of EC mapping patterns has underpinned grower's confidence in EC mapping technology. A number of growers in the region now base their chemical soil testing programs on the patterns displayed in processed EC maps as opposed to mixing soil cores collected in a transect from one corner of a paddock to the other. The geo-referencing of soil test sampling by soil type provides the grower with a powerful tool for monitoring soil nutrient trends over time and to determine wether nutrient input programs are maintaining, depleting or building macronutrient levels. Referenced, soil type targeted soil testing paves the way for site specific application of ameliorants such as lime, gypsum and mill by products where products are applied at the correct rate and spatial location within a paddock. In time this process will be further refined to the 'on the go' variable rate application of nutrients within paddocks. However, the practical application of variable rate technology requires a lot more research including an enhanced understanding of the stability of yield zones under a variety of seasonal conditions and over a number of crop cycles.

First ratoon phase of project

Pachymetra and nematodes resampling was repeated in the first ratoon phase of the project on the 12 April 2010. Sampling was again confined to the designated vegetation free measurement zones (1.8 x 5 metres) established at the end of TF plots as well as the TF cane plots. The plant cane and first ratoon nematode populations and Pachymetra spore counts were compared to better understand population dynamics and spore persistence in a crop and vegetation free environment (Table 6)

Soil group	**Average parasitic nematodes (per 200 ml)**				**Average Pachymetra (spores/kg of soil)**			
	Cane plots		Vegetation free		Cane plots		Vegetation free	
	Plant	Ratoon	14 months	27 months	Plant	Ratoon	14 months	27 months
A	468	481	17	18	4,024	3,209	1,857	1,333
B	1,604	1,109	36	13	2,813	5,737	4,703	1,766
C	2,021	845	55	*1,255	6,305	3,799	9,120	454
D	1,092	701	16	98	4,635	864	4,599	875
Average	1,296	784	31	346	4,444	3,402	5,070	1,107

* *no logical explanation for the abnormally high count, possibly due to sampling error*

Soil group	Organic Carbon %	**Free living nematodes**			
		Crop	Vegetation free	Crop	Vegetation free
		Plant cane	14 months	1^{st} Ratoon	27 months
A	0.69	503	312	382	359
B	0.84	977	784	615	255
C	1.1	1388	1032	300	365
D	0.81	962	834	450	421
Average	0.86	958	741	437	350

Table 6- Comparison of average parasitic, free living nematode and pachymetra persistence in a crop and vegetation free environments over time and crop class

In the vegetation free plots (bare fallow environment) the average plant parasitic nematode (PPN) populations had been reduced to insignificant numbers after 14 months. In this study extending the bare fallow period by an additional 13 months had little impact on PPN populations. The abnormally high count of PPN in soil group C after 27 months in a vegetation free environment cannot be explained and is most likely due to a sampling error. Free living nematodes (FLN) utilise organic carbon as a food source and explains the strong relationship between the beneficial free living nematode populations and the organic carbon % in the 4 soil groups in both the plant cane plots and the 14 month vegetation free zones. The 54% reduction in FLN populations between the plant cane and first ratoon phases may be attributed to an increase in predator numbers in a cane monoculture system attacking the free living nematode populations. The 53% reduction in FLN numbers from the 14 -27 month time frame in the vegetation free zones may be attributed to declining levels of organic carbon as a nematode feed source.

FLN play an important role in essential soil processes including nitrogen mineralization. This study highlighted to the growers in the project the importance of reducing tillage to conserve organic matter and enhance the environment for healthy FLN populations particularly in the lighter textured soils.

Analysis of nematode samples covers eight important PPN in a sugarcane system; Stunt, Root lesion, Spiral, Stubby root, Root knot, Ring, Rotylenchus and Dagger nematodes. Previous studies have shown that Lesion and Root knot are the most damaging of the PPN and have the greatest impact on cane yield. In this study, Lesion nematodes accounted for 55% of the PPN population in the plant cane plots and had risen to 94% of the PPN population by the first ratoon phase of the project. Trials undertaken by the Sugar Yield Decline Joint Venture project and other related trials demonstrated the value of soybean fallow legume cropping in reducing Lesion nematode populations and increasing organic matter levels.

The 14 month vegetation free status had little affect on average spore counts Pachymetra spore counts across the four soil groups. However, an additional 13 month bare fallow status had reduced Pachymetra spores by 78%, averaged across the four soil groups. It is important to emphasize that currently there is some difficulty in determining if spores are live or dead when observed under a microscope. The variety planted in the transect trial was Q208 which has an intermediate rating for Pachymetra susceptibility; this is reflected in the relatively low spore count in the plant and first ratoon phase of the project. The averaged Pachymetra count of 1,107 across the four soil groups is very low as the BSES regard a fallow count of 30,000 as being the threshold in fallow situation. It is unclear if the low level residual spores which have persisted for 27 months in a vegetation free environment are cable of increasing beyond the critical threshold if planted to a Pachymetra susceptible variety.

Stalk counts of the trial plots continued through to the hand harvesting of the first ratoon plots (September 2010). Stalks were counted at 209, 328 and 412 days after harvesting of previous plant cane crop (Table 7)

Soil Group	Treatment	24/02/10 209 days after harvest	23/06/10 328 days after harvest	15/09/10 412 days after harvest
A	Traffic free	10.7	9.1	8.9
A	Conventional	10.9	10.5	10.2
Group ave		*10.8*	*9.8*	*9.6*
B	Traffic free	8.3	7.2	7.0
B	Conventional	9.0	8.6	8.5
Group ave		*8.7*	*7.9*	*7.8*
C	Traffic free	8.6	7.3	7.1
C	Conventional	9.1	8.6	8.5
Group ave		*8.9*	*8.0*	*7.8*
D	Traffic free	8.9	7.4	7.4
D	Conventional	9.1	8.8	8.4
Group ave		*9.0*	*8.1*	*7.9*

Table 7- Average stalks per square metre for traffic free and conventional plots and average stalks per square metre by soil groups

There was no statistical difference between the average stalk counts across the four soil groups. However, average stalks counts in the conventional plots were higher than the traffic free plots for all soil groups. This is attributed to the trial design and the weather conditions during the active growth stage of the crop. Waterlogged paddocks coupled with windy conditions during February resulted in significant crop lodging particularly in the traffic free plots as buffer rows only extended the length of the measurement rows (12 metres total). In contrast, the conventional measurement rows are protected by buffer rows which extend the full length of the transect (360 metres). This situation was exasperated by cyclone Ului which passed through the central region on the 21 March 2010. Wind was channelled through the largely crop free trial transect causing significant lodging and stalk snapping in the exposed traffic free plots. Following cyclone Ului the average reduction in stalks per square metre for the traffic free plots was 15.4% while the conventional plots only suffered a 4.2% reduction respectively (Figure 6)

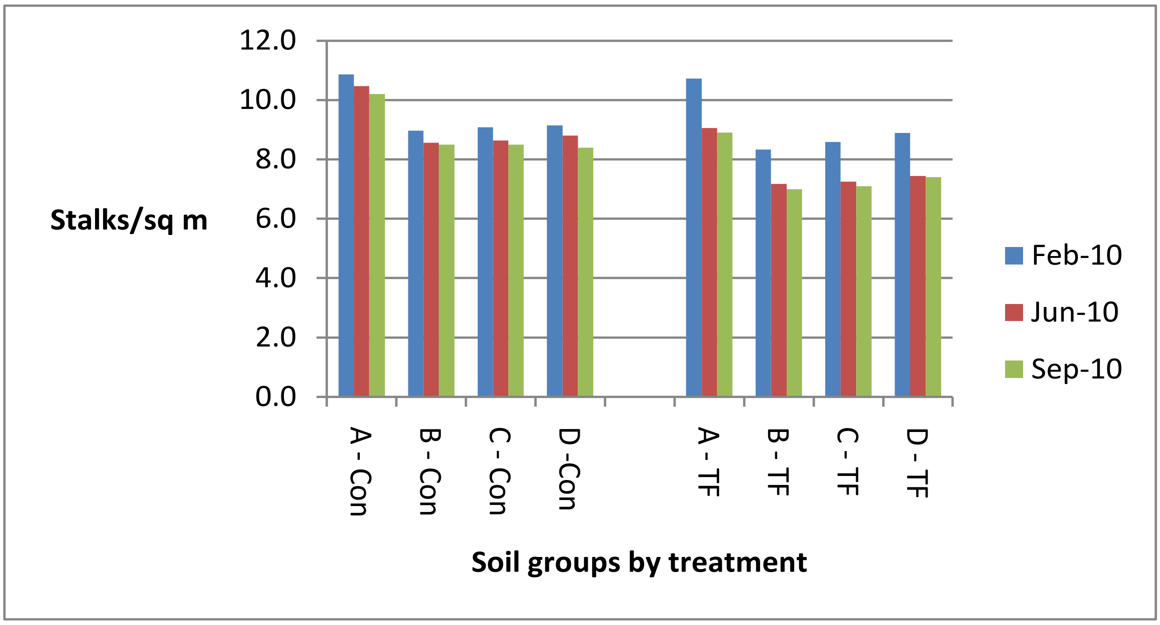

Figure 6- Relative reduction in stalks per square metre of the exposed traffic free (TF) plots compared to the more protected conventional (con) plots across soil groups following cyclone Ului

The first ratoon plots were hand harvested on the 20 September 2010. Statistically there was no significant difference in yield or tonnes of sugar per hectare across the soil groups (Figure 7).

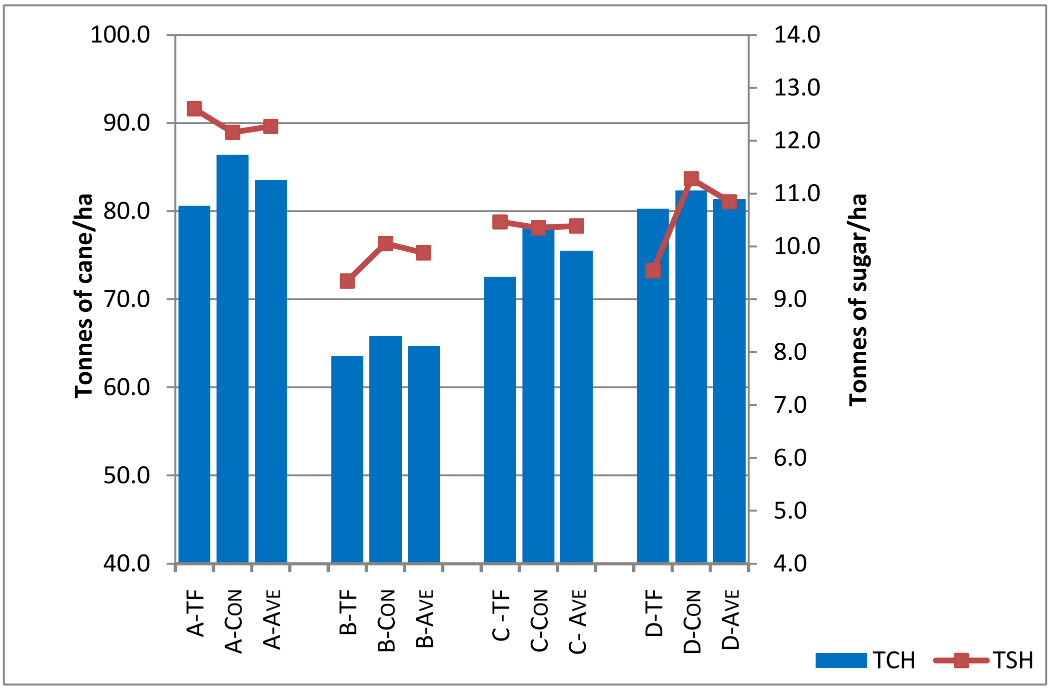

Figure 7- Average yield and tonnes of sugar per hectare for traffic free (TF) and conventional (Con) plots for each soil group and average yield and tonnes of sugar per hectare for individual soil groups

The affects of cyclone Ului on final stalk numbers had influenced the integrity of the hand harvested yield data for the first ratoon phase of the trial. This was confirmed by the variability in yield depicted in patterns from a processed high resolution satellite imagery capture over the study site in June 2010 (Figure 8). These patterns reflected the relative yield variability that occurred along the trial transect

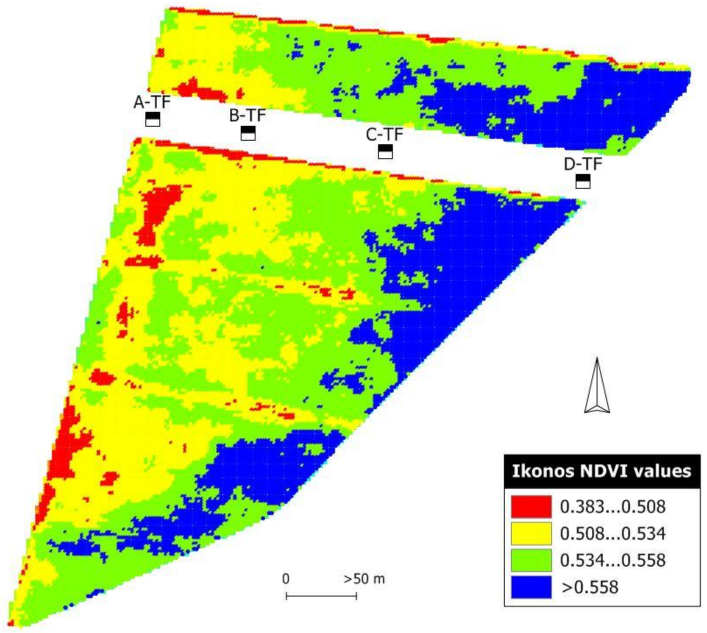

Figure 8- Processed satellite image (June 2010) with NDVI mapping patterns indicating heavier yielding section along the eastern section of the block (dark blue zone) through to lighter yielding areas on the western side of the site. The soil group plot locations are indicated along the trial transect

Due to the weather and cyclone compromised plots within the trial transect a decision was made to calibrate the NDVI (normalised difference vegetation index) yield patterns evident in the processed satellite image captured in June 2010. Fourteen geo-referenced hand harvest sites were selected from patterns evident in the NDVI mapping layer. Millable stalks were harvested from 5 metres of row and weighed on a portable weigh platform trailer. A strong correlation existed between the hand harvested data and the corresponding NDVI values (Figure 9). The generated yield map confirmed the variability in yield that occurred along the trial transect and corresponded closely to the contrasting soil group boundaries displayed in the EC mapping patterns (Figure 10). This study indicated that NDVI patterns reflected in high resolution satellite imagery provide a reasonably accurate indication of the yield variability that occurred within the study site.

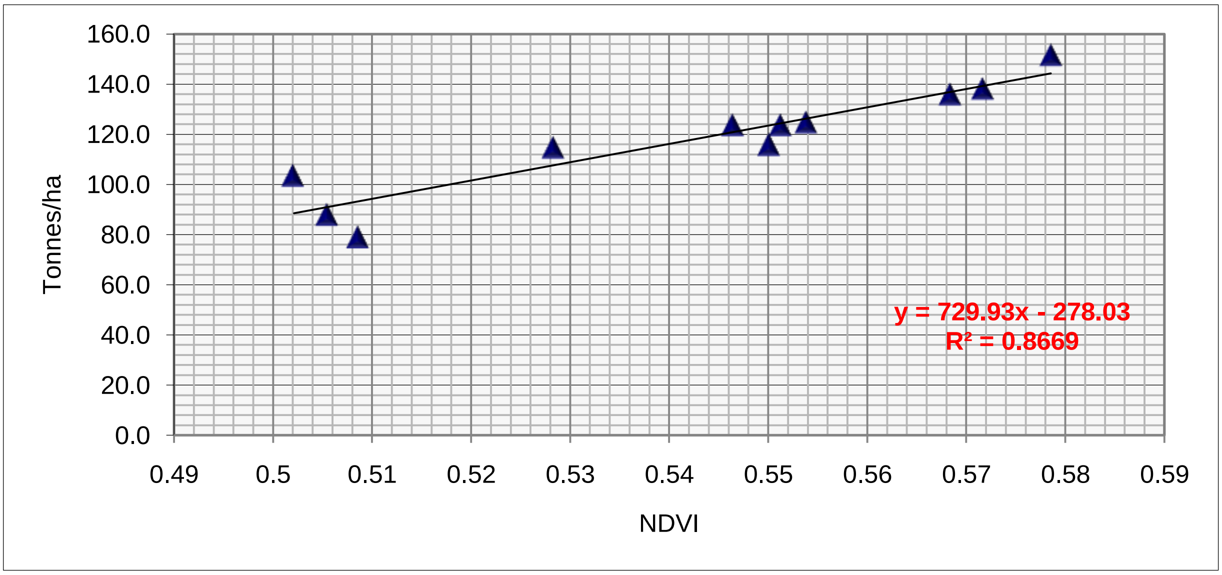

Figure 9- A strong correlation was evident from the referenced hand harvested yield data and corresponding NDVI values from processed satellite imagery

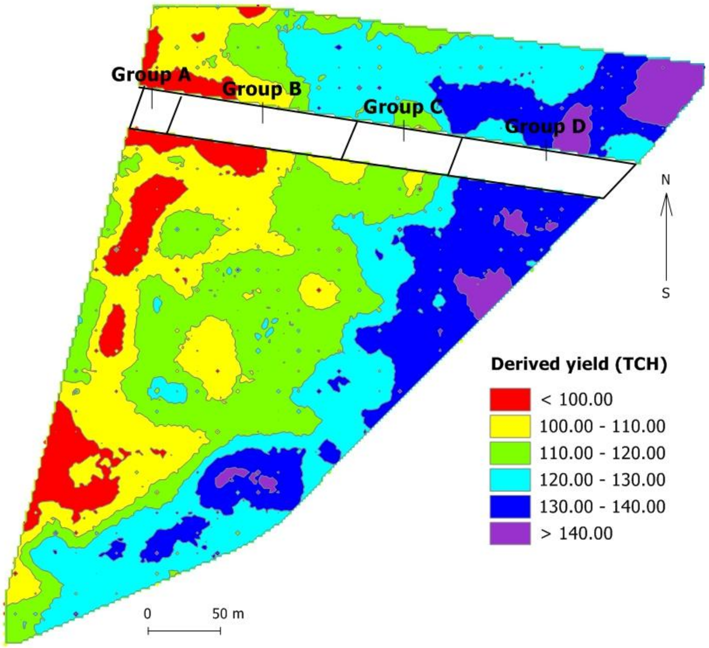

Figure 10- Variability in yield defined by processed satellite imagery relates well to contrasting soil groups defined by EC soil mapping

Two additional borehole sites and hand harvesting locations were selected during the harvesting operation when the presence of water in various parts of the paddock related to visual differences of crop height. The two strategically selected hand harvest sites based on visual changes in crop height provided additional validation that NDVI mapping patterns relate well to within- paddock yield variability (Figures 10 (a) and (b))

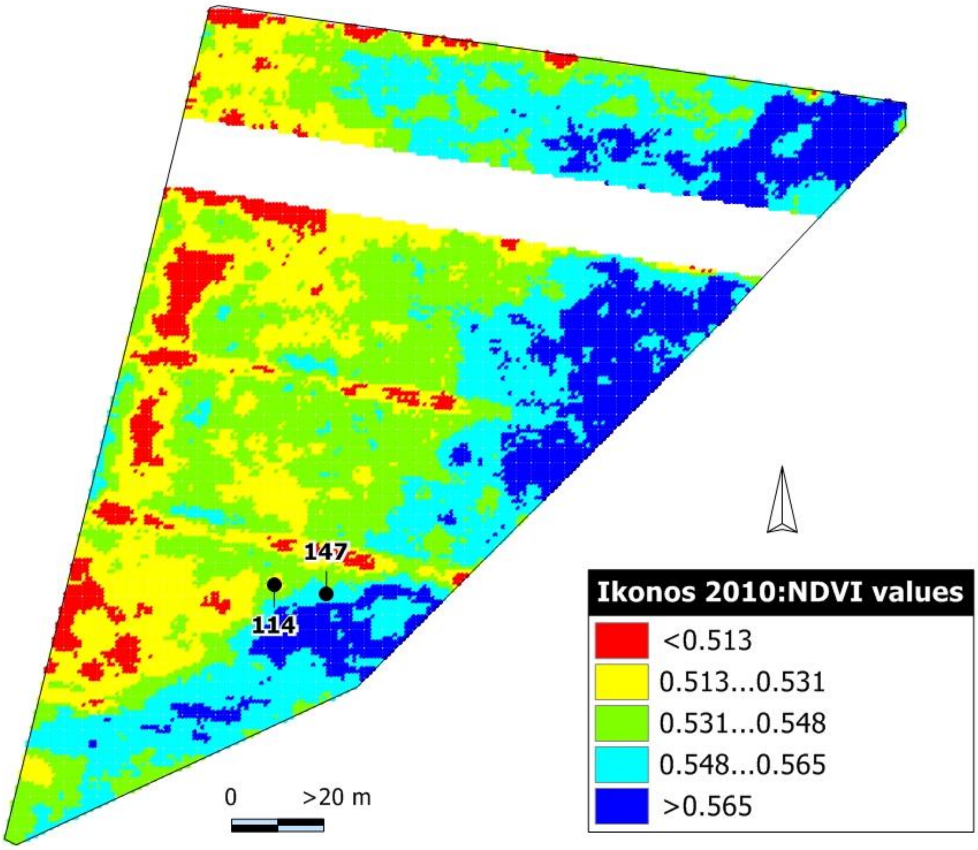

Figure 10 (a)- Variability in yield from referenced hand harvest yield data accurately defined in NDVI mapping patterns

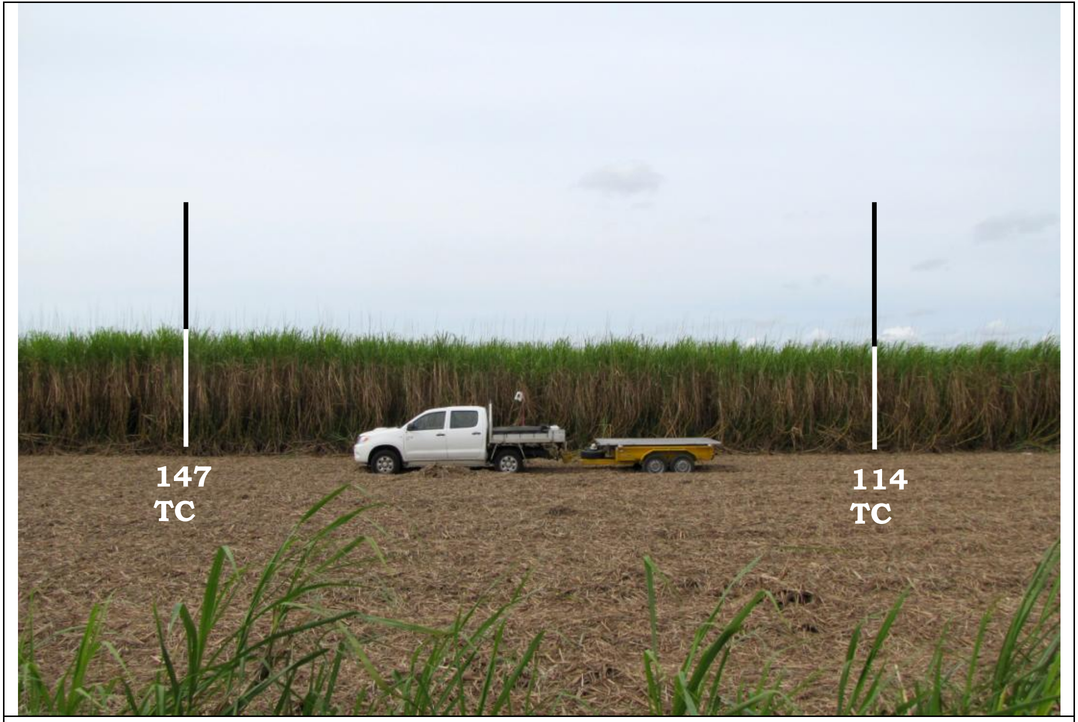

Figure 10 (b)- Referenced hand harvest sites validating variability in growth patterns reflected in NDVI mapping patterns

The change in yield between the two referenced sites also related well to the transition in mapping patterns evident in the EC soil map. The two referenced sites were revisited for crop growth assessment two months after harvest; the change in contrasting soil properties accurately reflected the differences in crop ratoonability (Figures 11 (a) and (b))

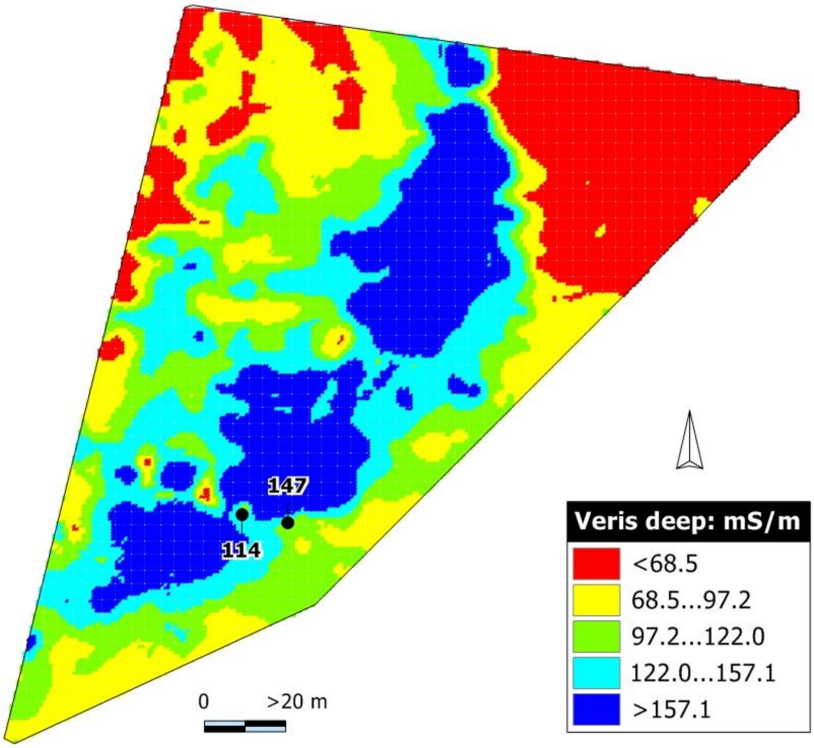

Figure 11 (a)- Hand harvested yield values corresponding to changes in EC mapping patterns

Figure 11 (b)- Variability in yield corresponding to visual changes in soil properties validating the pattern change evident in the EC mapping layer

An elevation/topography mapping layer was developed through the processing of elevation data collected during the Veris soil mapping operation using Manifold ® GIS software. Changes in yield between the two referenced hand harvest sites also related well to transitioning elevation/topography mapping patterns (Figures 12 (a) and (b)

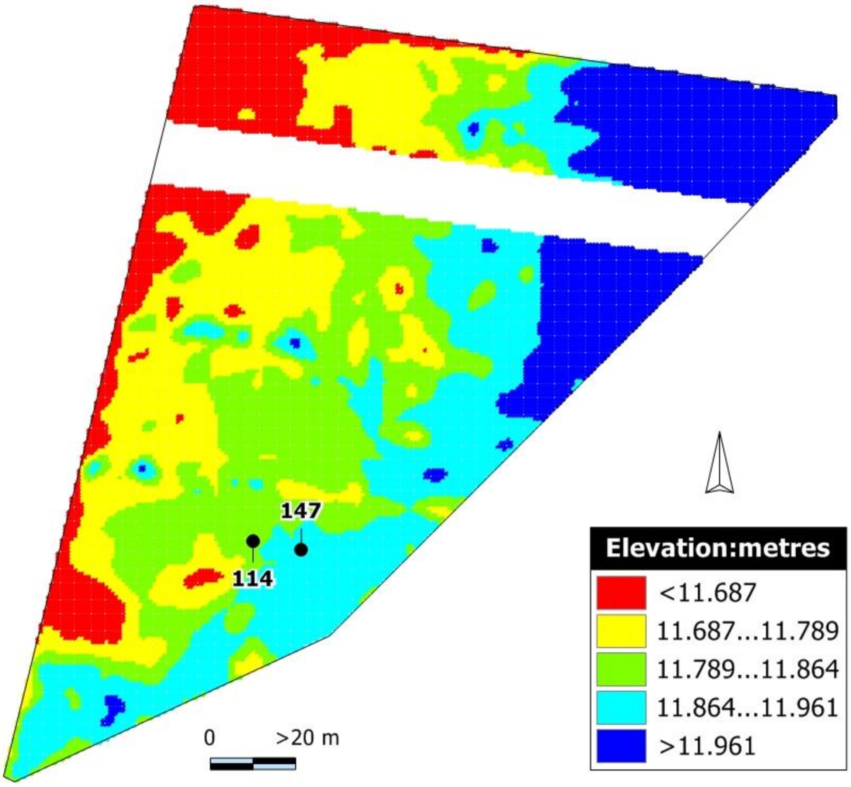

Figure 12 (a)- Changes in yield reflected in the transition from the well elevated eastern side of the study site to the relatively poorly drained western side of the paddock

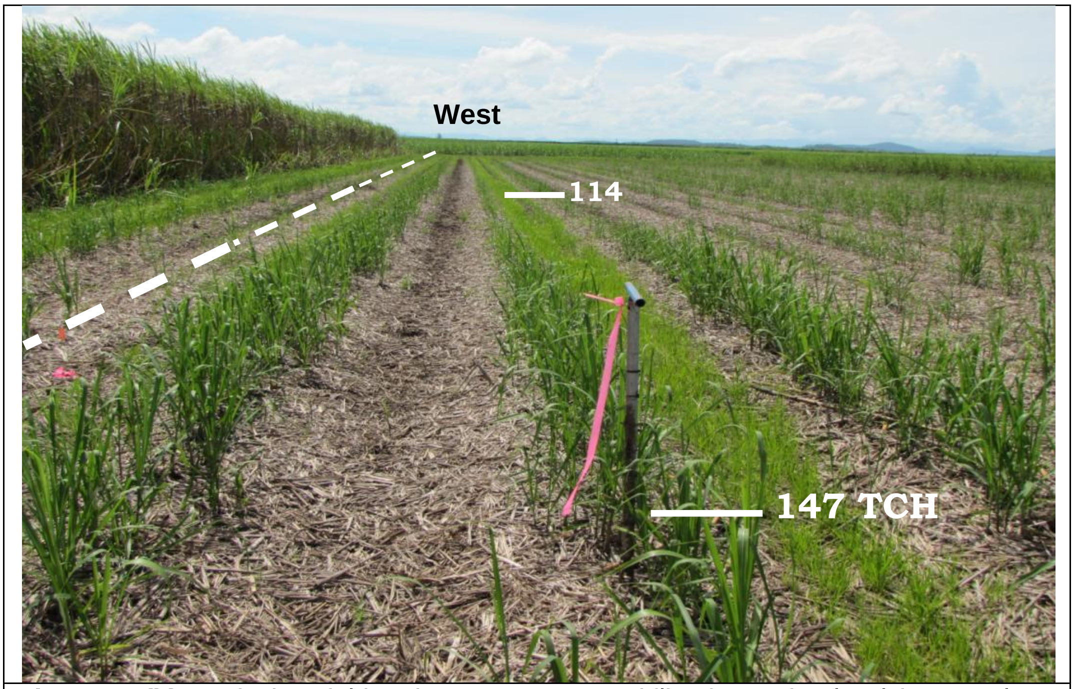

Figure 12 (b)- Reducing yield and poor crop ratoonability due to the low lying, poorly drained sector along the western side of the study site which is reflected in the elevation mapping layer

This project in conjunction with results from the BPS001 project has identified that yield is influenced by a complex interaction of variables and that progressing the management of within- paddock variability is underpinned by the knowledge of these agronomic factors. However, the project has also identified that yield is largely influenced by the physical properties of the soil (defined by EC mapping) and their spatial location within the topographical landscape (defined by digital elevation layer). In a precision agricultural context it is apparent that managing within paddock variability is enhanced where growers have access to three key spatial mapping layers, namely:

- Soil mapping data accessible through EC soil mapping surveys
- Digital elevation data which can be obtained through tractors equipped with RTK- GPS technology or from EC mapping surveys
- Yield data from processed satellite imagery or yield monitors on harvesters

Although the integrity of the 2010 yield data generated through the hand harvesting of the plots across the soil groups was compromised by cyclonic conditions the ground-truthing of NDVI yield patterns confirmed the relative changes in crop growth across the four soil groups. The relationship between contrasting soil texture properties and their relative spatial position in the landscape has provided an important insight into understanding the reasons for within-paddock yield variability. This information coupled with an enhanced appreciation of the interaction of variables that drive crop growth has facilitated the development of a number of possible management strategies to manage within-paddock variability, namely;

- Site specific mechanical tillage strategies based on EC mapping and a knowledge of associated soil properties (soil texture data)
- Conservation of organic matter through the adoption of zonal tillage strategies with intensity of tillage operations modified by knowledge of soil properties
- Site specific application of ameliorants defined by EC mapping zones and site specific soil analysis
- Sugarcane variety selection based on adaptation to defined soil properties and tolerance of waterlogged conditions
- Within-paddock variation in bed height defined by topography and soil type to minimise the affects of water logging in low lying areas of paddocks
- Fitting of automated base cutter height controllers on harvesters to accommodate changes in bed height
- Selection of fallow crops influenced by knowledge of soil properties and resistance to soil borne diseases such as Lesion and Root knot nematodes

This project in conjunction with the BPS001project has identified some of the problems in progressing “on the go” variable rate application of nutrients as the stability of yield zones defined by processed satellite imagery is not well understood. Defining specific nutrient inputs of spatially defined yield zone must be defined by the yield potential of the zones themselves. Further research is required to determine the stability of defined zones over a number of crop cycles and seasonal conditions.

In a PA context, this study in conjunction with the BPS001 project has defined some of the issues that limit the practical progression of ‘on the go’ variable rate application of nutrients. Specifically, it is difficult to determine the application rate of inputs if the yield potential of a defined zone is not known (despite access to soil chemical analysis). It is likely that poorly drained, low lying sections of a paddock will yield poorly in a wet year, however, in a dry year the same spatial zone may have a high yield potential. Further research is required to determine the stability of yield zones over time and different seasonal conditions

Intellectual Property and Confidentiality:

(If there is any protected Project Technology, e.g. information that has been kept confidential, such as equipment specifications, patentable knowledge please outline. Is there anything in this report that should be treated as confidential, and if so under what circumstances?)

No protected technology was used during the project and all the results of the trial and associated project activities are in the public domain and not constrained by confidentiality issues

Capacity Building:

(How has the Group’s capacity to conduct R&D and implement better farming systems been enhance?)

The Homebush Innovative Growers group have initiated and managed a number of GGIP over the past 8 years and in doing so have a full realisation of the need to underpin new management strategies with credible scientific studies. Members of the group have developed the capacity to confidently promote research results to the wider community and integrate project findings into their own farming enterprises.

Outcomes:

(What benefits have been achieved or are expected from the project, and what more has to happen to get the full benefit from the project? How do the expected benefits compare with those predicted at the start of the project, as outlined in the Application?)

Growers and extension staff associated with the project now view the management of sugarcane in a completely different light. There is no longer a reliance on “silver bullet” recipes for improving productivity and profitability. A Precision Agricultural approach to sugarcane production provides a pathway identifying and managing variability within-paddocks. Management strategies incorporate an understanding of the interaction of variables that influence yield including soil texture properties, surface and sub-surface drainage, disease issues, cane variety adaptability and soil chemical properties, to name a few. Modification of tillage intensity influenced through an understanding of soil texture properties and the benefits of conserving organic matter will help reduce erosion and improve the quality of water leaving paddocks. Selection of varieties based on adaptability to specific soil properties and topographical positioning in the landscape (drainage issues) should improve the uptake of applied nutrients with an associated relative improvement in productivity and water quality.

Collaborators in the project have an intricate knowledge of the key GIS mapping layers required to progress PA in sugarcane and manage within-paddock variability. A number of site specific practical management strategies are being developed by growers as consequence of the diverse range of studies and measurements undertaken during the course of this project. These strategies will significantly influence productivity and improve profitability and environmental sustainability

Environmental Impact:

(Outline any adverse or beneficial environmental impacts of conducting the Project and/or implementing its findings)

There have been no negative impacts on the environment through activities conducted in the project

Communication and Adoption of Outputs:

(Outline any communication activities that have been conducted and any that are planned. How has SRDC been acknowledged or involved? Have any lessons from the project been applied by members of the Group, or others?

Project progress, findings and results have been widely communicated across the region via a number of pathways:

- Annual BSES field day events where posters and soil cores and associated properties relating to EC and yield patterns were displayed and discussed
- Project results presented at annual trial share information days hosted by the BSES; trial data and project findings are presented to regional extension staff and leading district growers
- Grower group field trip visits from the Burdekin and Ingham. Incorporated in these field days were demonstrations at the trial site of bulk density sampling, water infiltration and soil resistivity measurements across soil groups identified by EC mapping
- Power point presentations delivered to Reef Protection Officers and senior reef regulation DERM staff in both Mackay and Brisbane to illustrate the potential of PA approaches and new technologies to improve the quality of water leaving sugarcane paddocks.
- Guest speaker presentations to the Reef Catchments annual grower meeting where the results and findings of the project were incorporated into the delivery
- Power point presentation to the Burdekin Productivity Services annual general meeting where again the project findings were incorporated into the presentation
- Two ABC rural radio interviews covering the aims and findings of the project
- Results from this project were incorporated into a poster delivered at the 2011 ASSCT conference in Mackay

The SRDC funding and support was acknowledged at all project extension events. The Homebush grower group project has close connections and associations with the Reef Catchments project titled Catalyst and this group of innovative growers are incorporating components of the project findings into their suite of management practices.

The Homebush Innovative Grower Group would like to thank members of AgriServe and BSES for their assistance in the hand harvesting of trial plots in the plant cane and first ratoon phases.

Recommendations:

(What recommendations would you make as a result of the project, including suggestions for further research and development?)

This GGIP project in conjunction with the BPS001 project (2007-2011) has established the key GIS spatial layers required to progress PA in a sugarcane production system. In addition the ground-truthing of EC and digital elevation mapping layers has provided a sound foundation for the development of site specific strategies to manage within paddock variability. The calibration of NDVI mapping patterns has provided some confidence in the ability of remote sensing technology to differentiate areas of variable crop growth within a paddock.

During the project a number of areas requiring further research have been identified. This additional research is regarded as being critical to progressing PA in the future. Variable rate application (VRA) technology is often seen as being the ‘holy grail’ of PA. To date VRA is commonly based on supplying the macronutrient (particularly nitrogen) deficiencies identified through geo-referenced chemical analysis results from zones identified in EC mapping programs. However, NDVI and yield monitor mapping patterns often display large within-paddock yield variability in crop growth. VRA nutrient programs based on chemical analysis alone is regarded as being flawed if the yield potential of a spatial zone is not considered. Further research is required to determine the stability of yield potential zones as defined by NDVI or yield monitors on harvesters. This research would ideally incorporate the analysis of yield mapping patterns over a number of crop cycles and seasonal conditions.

Field observations and ground-truthing of NDVI patterns established that poorly drained soils positioned in low lying areas of the paddock are the main drivers of poor within-paddock yield zones. Similar results were obtained by the BPS001 project at the Trebonne study site west of Ingham. It is unclear if the poor yield in these zones can be attributed to:

- A nitrogen (N) deficiency due to denitrification in waterlogged soils
- A sugarcane root system so compromised by extended waterlogged conditions that the plant is unable to extract nutrients

From a VRA perspective, the answer to the above issues are fundamental in determining if more N should be applied to offset the losses through denitrification or the application of N be reduced in these zones as the compromised root system is unable to effectively extract N. Further research is required in these areas in order to better determine N rates in zones subject to extended anaerobic conditions. It is evident that yield declines with the ageing of ratoon crops within a crop cycle. It is unclear if nutrient inputs need to be increased in an attempt to maintain yield or reduced due to a diminishing yield potential associated with the ageing of the ratoons. Again from a VRA and a PA perspective, further research is required in this area to accurately determine nutrient inputs.

Analysis of strategic spatial mill yield data over time may provide an indication of the adaptability of various sugarcane varieties to specific soil texture groups and growth performance in low lying areas subject to seasonal water logging. This analysis would need to incorporate digital elevation data and soil texture information derived from EC mapping patterns. Historic satellite yield data is available for most of the Mackay Sugar area and extensive areas have been EC mapped since 2001. RTK elevation data is increasingly accessible with the adoption of GPS navigation in the central cane growing region. The results from this comprehensive analysis of spatial data sets over a number of seasonal conditions may provide significant productivity gains where specific cane varieties are allocated to defined spatial zones in a PA context

Publications:

(List and attach copies (electronically if possible) of all articles, newsletters and other publications from the project.)

Article author: Bill Kerr
Article distribution: Qld Country Life and North Qld Register
Date: 11 August 2009

Mackay growers look for the next step in precision farming

Precision agriculture and new farming methods stemming from the Sugar Yield Decline Joint Venture (SYDJV) research program have helped Australian cane growers cut costs and boost productivity and sustainability in recent years but where do we look for the next management breakthrough?

Mackay cane growers Tony and John Bugeja, who farm 420 ha at Palmyra and Sunnyside with Tony’s son Mark, are convinced that some of the answers lie below the cultivation layer and are doing something about it

“Until now the industry has been in survival mode but with better sugar prices we need to take the next step towards improving productivity and cutting costs,” says Tony. “If we stand still long enough we’ll stagnate and if we stagnate we die.”

They are convinced that an improved knowledge of sub surface soil characteristics will result in a better understanding of what drives cane yields, an issue crucial to the industry taking the next step towards improved profitability

“Maximising productivity is vital to our economic survival,” says Tony, “but we can’t understand and manage yield variability without understanding the soil.”

The Bugejas have integrated of most the farming system principles developed by the SYDJV and consider that, based on current knowledge of soil and water dynamics, they have probably gone as far as they can go in modifying crop management to address yield variations. Further efficiency gains will require better understanding of all the factors that limit productivity on the diverse mix of soils.

They are members of Homebush Innovative Farmers group which is working with QPI&F farming systems agronomist John Hughes to conduct a long-term replicated trial on one of their six farms. The trial targets the identification of agronomic issues influencing yield variability and the subsequent development of zonal management techniques for spatially defined soil groups in the trial. The aim of the trial is to determine the yield potential of cane on paddock geo-referenced soil groups with known characteristics and to identify ways of maximising productivity from those soils with the best mix of water and nutrient management and precision agriculture.

John Hughes went on to explain that “A SRDC funded Precision Agriculture project is undertaking similar work on specific sites in the Burdekin and Ingham regions, researching the relationships in patterns from Electro magnetic soil mapping, yield monitors on harvesters and satellite imagery captures over the study sites.”

Over the next four years, the trial will compare soil bulk density values, soil penetration resistance, water infiltration and yield across defined soil groups in a conventionally grown, traffic-free crop, and bare soil environment. Physical measurements and chemical analyses will be extracted from vegetation free zones positioned at the end of each replicate cane plot along a 320 metre transect across the block with four identified soil groups. Half the plots in the trial will be ‘machinery-free’ to develop a better understanding of the response of the various soil groups to machinery compaction. Soil borne pests and disease infestations will be monitored by soil group and their persistence evaluated in a crop and vegetation free environment.

It is anticipated that the trial on the Bugejas’ farm at Rosella will provide information on the adaptability of certain sugarcane varieties to poor sub surface drainage issues and the potential and feasibility of variable variety planting within designated zones to address areas prone to water logging as identified and ground truthed through EM soil mapping and yield monitors

“Our soil types and yields vary greatly, not only on a farm basis but also within individual paddocks,” says Tony. “When yield variation occurs across a paddock comprised of different soil types farmers usually try to raise the production from the problem areas by applying more fertiliser, this may not necessarily fix the problem as the issues causing the drop in yield may not be nutritional.”

“We’re thinking now that rather than try to correct under-performing soils by adding more nutrients we might be better off financially maximising the yield potential of better performing soils. If we can identify precise locations of different soil types and understand the factors that cause yield variations we will be able to manage them better using precision agriculture techniques which may including variable rate fertilising on geo-referenced management zones within the paddock."

Tony suspects that some yield differences are influenced by compaction issues at harvest and soil penetration resistance measurements collected from the trial will help us better understand the response of the soil groups to the passage of heavy machinery.

"We need to know much more about what actually happens under the ground. The conventional approach of taking soil tests in the top layer without GPS referencing needs to be looked at and knowledge of sub surface soil characteristics will help us make better management decisions."

The Bugeja brothers are enthusiastic converts to the cause of adopting a holistic approach to soil and crop management to maximise yield potential and reduce nutritional inputs. Based on the preliminary trial results and the early findings of the SRDC,Precision agriculture research project they consider that an integrated systems approach to farming will produce better results than concentrating on individual issues in isolation. They accept that complex factors affect yield variability and there are no simple solutions.

Previous trials conducted by the Homebush group with SRDC funding evaluated variable rate planting, nutrition management, controlled traffic, soil mapping and strategic tillage but the results generated as many questions as answers.

"They showed that we needed more research to identify the next step. Hopefully this trial will put us on the right track. I'm much happier now than three years ago about understanding and managing the things that trigger yield variability."

The Bugejas have been using electro magnetic soil mapping since 2001 and the final areas will be EM mapped over the next couple of years. Tony regards it as a good management tool but not the only one that they need to use.

Each year they sit down with local soils expert Tony Crowley for several hours to discuss their fertilising program before briefing the contractor who does all fertilising on their six farms. All fertiliser is applied as Liquid One Shot using GPS guidance. They have used no bagged fertiliser for three years, not even for planting.

"Having a contractor apply liquid fertiliser is more accurate and saves a lot of time and money. We don't need a fertiliser truck or bag lifter and it frees up more time during the crushing."

The Bugejas have been gradually converting their paddocks to 1.8 m row spacing and controlled traffic. Planting is done with a dual row disc opener planter. Their ability to conduct zonal tillage operations will be increased following the purchase of a 3-row Howard CH2000 Rotavator fitted with zonal rippers under the Reef Rescue scheme.

This season they will trial a sonar detector on the base cutter of a GPS guided 1996 model Austoft harvester to try to minimise dirt going through the machine and get a more consistent ground job.

ENDS