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Technical Case Study – Ref 5.1.2b

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Assessment of RainMaker water treatment on soils and sugar cane at Mkuze, KZN

by Rory Milbank, Eco-Agri Consultants

1st July 2015 to 30th June, 2016

As independent consultant, Rory Milbank of Eco-Agri Consultants CC in Pietermaritzburg, was contracted by Dr Derek Askew of Rainmaker International, to monitor the changes and benefits to the soil and cane crop of irrigation water treated by the Rainmaker water treatment system.

The progress of the crops and soils on homogenous treated and untreated lands was monitored every three months. Penetrometer readings, visual observations, water samples, as well as Soil Health (S019), Soil Fertility (S007) and leaf analysis were tested by Brookside Laboratories of Ohio, USA.

The advantages or disadvantages of the system could then be measured.

The trial site was situated near Mkuze on a farm known as Kortplaas.

My initial observations were that the mainly Hutton soils were very high in magnesium and low in calcium, and thus prone to compaction and poor drainage.
Water quality from the Jozini dam was good except for a bicarbonate level of 151.74 ppm in which case, a level of <120ppm was ideal. The water pH was 7.89.

At the commencement of the trial on 1st July, 2015, the cane had been cut and was being ratooned.

The cane was irrigated by dripper lines with water from the Jozini dam.

IRRIGATION WATER ASSESSMENT

Test Date: 10th July,2015 **Client:**

Sample ID: Irrigation water

Water Parameter	Symbol	Unit	Test Level	Desirable Range
pH			7,89	<8.5
Hardness		ppm	86,44	<200
Conductivity		mmhos/cm or dSm	0,35	<1.5
Sodium Adsorption Ratio	SAR	mg/l	1,61	<4
Adjusted SAR		meq/l	1,94	<7
Adjusted Rna		meq/l	0	<6
pHc			8,2	<8.8
Residual Sodium Carbonate	RSC	meq/l	0,77	<1.9
Suspended Solids	SS	mg/l	0	<30
Salt Concentration	TDS	ppm	223,36	<1000
		ppm or mg/l		
Phosphorous	P	ppm or mg/l	<.2	<15.5
Potassium	K	ppm or mg/l	1,88	<10
Calcium	Ca	ppm or mg/l	15,9	<120
Magnesium	Mg	ppm or mg/l	11,29	<40
Manganese	Mn	ppm or mg/l	0,02	<0.2
Iron	Fe	ppm or mg/l	0,15	<1.0
Boron	B	ppm or mg/l	0,05	<0.5
Copper	Cu	ppm or mg/l	0,036	<0.2
Sulphates	SO4	ppm or mg/l	12,88	<90
Zinc	Zn	ppm or mg/l	0,04	<2.0
Sodium	Na	ppm or mg/l	34,41	<50
Aluminium	Al	ppm or mg/l	<.2	<5
Molybdenum	Mo	ppm or mg/l	0	<0.01
Chloride	Cl	ppm or mg/l	20,42	<140
Fluoride	F	ppm or mg/l	0	<1
Nitrate	NO3	ppm or mg/l	0,25	<5
Alkalinity		ppm or mg/l	124,36	<150
Bicarbonate	HCO3	ppm or mg/l	151,74	<120
Carbonate	CO3	ppm or mg/l	0	<15

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The above report shows the quality of the untreated water from the Jozini dam at the beginning of the trial period. The water quality was better at this time and deteriorated as the level of the dam dropped due to the drought. The major deterioration was in the case of the pH which rose from 7.89 to 7.98, and associated bicarbonates which increased from 151.74 ppm to 172.79 ppm. Hardness also increased from 86.4 to 100.5 ppm, EC from 0.35 to 0.41 dS/m and salt concentration from 223 to 262 ppm. This was a reflection of the higher Ca, Mg, K and Na levels in the water. Notable was the increase in Cl from 20.42 to 31 mg/L. Overall water quality was reduced from a C2S1 to a C2S2.

The table below shows the water quality at the end of the trial period in June, 2016.

IRRIGATION WATER ASSESSMENT

Test Date: 8th June,2016 **Client:**

Sample ID: Irrigation water

Water Parameter	Symbol	Unit	Test Level	Desirable Range
pH			7,98	<8.5
Hardness		ppm	100,51	<200
Conductivity		mmhos/cm or dSm	0,41	<1.5
Sodium Adsorption Ratio	SAR	mg/l	1,9	<4
Adjusted SAR		meq/l	2,49	<7
Adjusted Rna		meq/l	0	<6
pHc			8,09	<8.8
Residual Sodium Carbonate	RSC	meq/l	0,87	<1.9
Suspended Solids	SS	mg/l	0	<30
Salt Concentration	TDS	ppm	261,76	<1000
		ppm or mg/l		
Phosphorous	P	ppm or mg/l	<.2	<15.5
Potassium	K	ppm or mg/l	2,53	<10
Calcium	Ca	ppm or mg/l	18,05	<120
Magnesium	Mg	ppm or mg/l	12,92	<40
Manganese	Mn	ppm or mg/l	0,02	<0.2
Iron	Fe	ppm or mg/l	1,26	<1.0
Boron	B	ppm or mg/l	0,06	<0.5
Copper	Cu	ppm or mg/l	<.02	<0.2
Sulphates	SO4	ppm or mg/l	16,81	<90
Zinc	Zn	ppm or mg/l	<.04	<2.0
Sodium	Na	ppm or mg/l	43,38	<50
Aluminium	Al	ppm or mg/l	1,574	<5
Molybdenum	Mo	ppm or mg/l	0	<0.01
Chloride	Cl	ppm or mg/l	31,32	<140
Fluoride	F	ppm or mg/l	0	<1
Nitrate	NO3	ppm or mg/l	<.1	<5
Alkalinity		ppm or mg/l	141,61	<150
Bicarbonate	HCO3	ppm or mg/l	172,79	<120
Carbonate	CO3	ppm or mg/l	0	<15

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The trial consisted of an area drip irrigated with untreated water and another with water treated by the Rainmaker system.

The treated site on 8th October, 2015. In–row soil was soft, but the inter-row soil was hard.

Untreated area above and treated area below, after 50 mm of rain accompanied by hail on the 10th December 2015. The untreated area looked as though it had missed a nitrogen topdressing, but after discussion with the farmer, this was found not to be the case. The cane growth was much better in the treated crop.

The next assessment was done at the end of April 2016 in another treated and untreated site of the test lands. Profile pits were dug, soil observations were made and the listed soil tests were done.

The cane of both areas, treated and untreated, were similar in height, however the treated cane showed a more vibrant green colour.

The soil in the untreated area was very compact, contained hard clods and root depth was restricted to approximately 30 cm. See below.

The soil in the treated area was soft and friable. (See below)

In the treated area, the soil was a great deal softer, relatively clod free and the rooting depth was ≥1.2 m.

The stalks of the treated cane were bowed outwards searching for space.

The picture below shows the difference in internode length between the treated (top) versus the untreated cane (bottom).

It was noted that the stalks from the treated cane were largely free of Eldana Borer whereas it was present in the untreated cane.

The following four Soil Health Reports show the results of the treated versus untreated areas at a depth of 150 mm and 900 mm from soil profile pits.

The Rainmaker treated water definitely had a moderating effect on the nutrient balances and levels in the soil, raising nutrient availability and reducing sodium at the same time.

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Report Date:
3rd May,2016

Soil Health Analysis Report

Lab Number		3
Sample Location		KORTPLASS
Sample ID 1		T-S
Sample ID 2		0
NPK		
Total Available N (kg/ha)		76
Available Inorganic N (kg/ha)		17
Available Organic N (kg/ha)		59
Value of N Saved	R	-
Total Available P as P (kg/ha)		28
Available Inorganic P as P (kg/ha)		0
Availlable Organic P as P (kg/ha)		28
Available Potassium as K (kg/ha)		685
NPK Value as R/ha	R	-
Soil Health Results		
Respiration (Solvita CO2-C) (ppm)		57,2
Water Extractable Organic Carbon (ppm)		170,4
Water Extractable Organic Nitrogen (ppm		19,6
Organic C:N		8,7
Organic N:P		2,8
% Microbially Active Carbon		33,6
Soil Health Calculation		9,4
Cover Crop Mix	50% Legume 50% Grass	
Secondary and Minor Nutrients (H3A Extractable)		
Calcium (kg/ha)		437
Magnesium (kg/ha)		419
Sodium (kg/ha)		128
Sulfur (ppm)		24
Boron (ppm)		1,20
Iron (ppm)		659
Manganese (ppm)		52
Aluminum (ppm)		698
Copper (ppm)		8,59
Zinc (ppm)		0,86
Calcium+Magnesium/Aluminum		0,55
Ca:Mg		1,04
% P Saturation Iron + Aluminum		0,00
% P Saturation Calcium		0,00
Plant Effective CEC (meq/100 g)		6,13
Ca Need (kg/ha)		1429
Ca % for Plant Effective CEC		15,9

	14 - 20
	0.7 - 2.6
	13 - 40+
	4 - 6 (15 in RR)
	0.5 - 1
	1 - 3

The above result is for the treated area at a depth of 150 mm. Total available N, P and K were 76, 28 and 685 kg/ha respectively, and Soil Health Score was 9.4 which is good.

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Report Date:
3rd May, 2016

Soil Health Analysis Report

Lab Number		4
Sample Location		KORTPLASS
Sample ID 1		T-D
Sample ID 2		0
NPK		
Total Available N (kg/ha)		12
Available Inorganic N (kg/ha)		6
Available Organic N (kg/ha)		6
Value of N Saved	R	-
Total Available P as P (kg/ha)		0
Available Inorganic P as P (kg/ha)		0
Availllable Organic P as P (kg/ha)		0
Available Potassium as K (kg/ha)		85
NPK Value as R/ha	R	-
Soil Health Results		
Respiration (Solvita CO2-C) (ppm)		12,2
Water Extractable Organic Carbon (ppm)		101,0
Water Extractable Organic Nitrogen (ppm		5,3
Organic C:N		19,0
Organic N:P		1,8
% Microbially Active Carbon		12,1
Soil Health Calculation		2,8
Cover Crop Mix	70% Legume 30% Grass	
Secondary and Minor Nutrients (H3A Extractable)		
Calcium (kg/ha)		412
Magnesium (kg/ha)		345
Sodium (kg/ha)		311
Sulfur (ppm)		10
Boron (ppm)		1,74
Iron (ppm)		979
Manganese (ppm)		45
Aluminum (ppm)		1229
Copper (ppm)		9,93
Zinc (ppm)		0,79
Calcium+Magnesium/Aluminum		0,28
Ca:Mg		1,19
% P Saturation Iron + Aluminum		0,00
% P Saturation Calcium		0,00
Plant Effective CEC (meq/100 g)		7,41
Ca Need (kg/ha)		1846
Ca % for Plant Effective CEC		12,4

14 - 20
0.7 - 2.6
13 - 40+
4 - 6 (15 in RR)
0.5 - 1
1 - 3

The above result is for the treated area at a depth of 900 mm. Total available N, P and K were 12, 0 and 85 kg/ha respectively, and Soil Health Score was 2.8 and low, which was expected at that depth.

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Report Date:
2nd May,2016

Soil Health Analysis Report

Lab Number		1
Sample Location		KORTPLASS
Sample ID 1		UT-S
Sample ID 2		0
NPK		
Total Available N (kg/ha)		28
Available Inorganic N (kg/ha)		2
Available Organic N (kg/ha)		26
Value of N Saved	R	-
Total Available P as P (kg/ha)		11
Available Inorganic P as P (kg/ha)		0
Availlable Organic P as P (kg/ha)		11
Available Potassium as K (kg/ha)		231
NPK Value as R/ha	R	-
Soil Health Results		
Respiration (Solvita CO2-C) (ppm)		39,8
Water Extractable Organic Carbon (ppm)		161,6
Water Extractable Organic Nitrogen (ppm		11,9
Organic C:N		13,6
Organic N:P		1,5
% Microbially Active Carbon		24,6
Soil Health Calculation		6,8
Cover Crop Mix	60% Legume 40% Grass	
Secondary and Minor Nutrients (H3A Extractable)		
Calcium (kg/ha)		479
Magnesium (kg/ha)		515
Sodium (kg/ha)		379
Sulfur (ppm)		8
Boron (ppm)		0,95
Iron (ppm)		492
Manganese (ppm)		52
Aluminum (ppm)		536
Copper (ppm)		6,96
Zinc (ppm)		0,99
Calcium+Magnesium/Aluminum		0,83
Ca:Mg		0,93
% P Saturation Iron + Aluminum		0,00
% P Saturation Calcium		0,00
Plant Effective CEC (meq/100 g)		5,95
Ca Need (kg/ha)		1334
Ca % for Plant Effective CEC		18,0

14 - 20
0.7 - 2.6
13 - 40+
4 - 6 (15 in RR)
0.5 - 1
1 - 3

The above result is for the untreated area at a depth of 150 mm. Total available N, P and K were 28, 11 and 231 kg/ha respectively, and Soil Health score at 6.8 was low at the depth of 150 mm. All these parameters and others were lower than the treated lands (See Table 1).

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Report Date:
3rd May,2016

Soil Health Analysis Report

Lab Number		2
Sample Location		KORTPLASS
Sample ID 1		UT-D
Sample ID 2		0

NPK

Total Available N (kg/ha)		5
Available Inorganic N (kg/ha)		4
Available Organic N (kg/ha)		1
Value of N Saved	R	-
Total Available P as P (kg/ha)		0
Available Inorganic P as P (kg/ha)		0
Availlable Organic P as P (kg/ha)		0
Available Potassium as K (kg/ha)		87
NPK Value as R/ha	R	-

Soil Health Results

Respiration (Solvita CO2-C) (ppm)		7,1
Water Extractable Organic Carbon (ppm)		118,2
Water Extractable Organic Nitrogen (ppm		2,7
Organic C:N		43,6
Organic N:P		0,9
% Microbially Active Carbon		6,0
Soil Health Calculation		2,2
Cover Crop Mix	80% Legume 20% Grass	

Secondary and Minor Nutrients (H3A Extractable)

Calcium (kg/ha)	461	
Magnesium (kg/ha)	370	
Sodium (kg/ha)	372	
Sulfur (ppm)	8	14 - 20
Boron (ppm)	1,67	0.7 - 2.6
Iron (ppm)	937	13 - 40+
Manganese (ppm)	45	4 - 6 (15 in RR)
Aluminum (ppm)	1161	
Copper (ppm)	10,78	0.5 - 1
Zinc (ppm)	0,67	1 - 3
Calcium+Magnesium/Aluminum	0,32	
Ca:Mg	1,25	
% P Saturation Iron + Aluminum	0,00	
% P Saturation Calcium	0,00	
Plant Effective CEC (meq/100 g)	7,48	
Ca Need (kg/ha)	1818	
Ca % for Plant Effective CEC	13,8	

The above result is for the untreated area at a depth of 900 mm.
Total available N, P and K were 5, 0 and 87 kg/ha respectively, and Soil Health Score was 2.2 which was lower than the 2.8 of the treated area at the same depth of 900 mm. All these parameters and others were lower than those of the treated lands.

Table 1. A comparison of Soil Health Score results at 15 cm depth

	Treated – 15 cm	Untreated – 15 cm
Total available N	76 kg/ha	28 kg/ha
Total available P	28 kg/ha	11 kg/ha
Total available K	685 kg/ha	231 kg/ha
Respiration – Solvita CO_2	57.2 ppm	39.8
Water Extractable Organic Carbon	170.4 ppm	161.6
Water Extractable Organic Nitrogen	19.6 ppm	11.9
Organic C:N	8.7	13.6
Organic N:P	2.8	1.5
% Microbially Active carbon	33.6	24.6
Soil Health Score	9.4	6.8
Calcium kg/ha	437	479
Magnesium kg/ha	419	515
Sodium kg/ha	128	379
Sulphur ppm	24	8
Boron ppm	1.2	.95
Iron ppm	659	492
Manganese ppm	52	52
Aluminium ppm	698	536
Copper ppm	8.59	6.96
Zinc ppm	.86	.99
Calcium + Magnesium / Aluminium	.55	.83
Ca:Mg	1.04	.93
Plant effective CEC meq/100g	6.13	5.95

There is a favourable trend in most of the elements measured in the Soil Health Score as well as improved availability of most of the nutrients. The reduction in the sodium levels is a valuable contribution. These same trends can be seen in the 150 and 900 mm samples and were seen in the Soil Fertility reports (S007).

What is most important, apart from nutrient comparisons, is the increase in general Soil Health over a relatively short time frame. Improvements in respiration, WEOC, WEON, C:N, N:P and microbial active carbon all played a role in these results.

The resultant plant health seems to have had a large positive impact on the reduction in the prevalence of Eldana borer.

Eldana was not present in the top stalk from the treated area, but was indeed present in the lower stalk from the untreated area. Note the greater vigour in the growth of the treated cane!

Table 2. A comparison of Soil Health Score results at 90 cm depth.

	Treated – 90 cm	Untreated – 90 cm
Total available N	12 kg/ha	5
Total available P	0 kg/ha	0
Total available K	85 kg/ha	87
Respiration – Solvita CO_2	12.2 ppm	7.1
Water Extractable Organic Carbon	101 ppm	118.2
Water Extractable Organic Nitrogen	5.3 ppm	2.7
Organic C:N	19	43.6
Organic N:P	1.8	.9
Soil Health Score	2.8	2.2
Calcium kg/ha	412	461
Magnesium kg/ha	345	370
Sodium kg/ha	311	372
Sulphur ppm	10	8
Boron ppm	1.74	1.67
Iron ppm	979	937
Manganese ppm	45	45
Aluminium ppm	1229	1161
Copper ppm	9.93	10.78
Zinc ppm	0.79	.67
Ca+Mg / Aluminium	.28	.32
Ca:Mg	1.19	1.25
Plant effective CEC meq/100g	7.41	7.48

My observations are that on some Soil Health Tests where there is a greater level of nitrogen present in the treated area, the Water Extractable Organic Carbon level is lower due to it having been consumed by the soil biome and converted to organic nitrogen.

In this case, I believe this was possibly due to the irrigation being turned off to induce drought stress to assist in the ripening of the crop. Crop stress would halt the flow of organic carbon via the roots to the soil biome which in turn will consume the available source of nutrients.

This was also enhanced by an improved soil structure allowing for more efficient respiration which in turn enables the proliferation of soil organisms which feed on the organic carbon.

Overall, at 900 mm the Soil Health Score was 2.8 for treated lands and 2.2 for untreated lands, so the Rainmaker water treatment made a difference at this deep level as well.

It is a known fact that the Rainmaker water treatment system ensures cleaning of the irrigation system. According to the farmer in this case, the system was around 12 years old and dripper blockages occurred at the field perimeter where old sediment settled from elsewhere in the system. Flushing of the end lines would have assisted in this instance.

The effect of the water stress induced by switching off the irrigation can be seen in the picture below.

Soil Fertility Tests (S007) conducted on the 15th October, 2015

kg/ha

BROOKSIDE LABORATORIES, INC. 74362-2

SOIL AUDIT AND INVENTORY REPORT

Name _____ City George State KZN

Independent Consultant Eco - Agri Consultants CC Date 2015/10/15

Sample Location	MKUZE			PCT-T		PC-UT	
Sample Identification							
Lab Number				0571-1		0572-1	
Total Exchange Capacity (ME/100 g)				19.16		12.74	
pH	Buffer (SMP/Sikora)			7.0		6.8	
	H_2O (1:1)			6.2		6.3	
Organic Matter (humus) %				4.19		4.73	
ANIONS	SOLUBLE SULFUR*		ppm	17		15	
	PHOSPHORUS MEHLICH III	kg/ha	P as P_2O_5	108		31	
			ppm of P	21		6	
	PHOSPHORUS BRAY II	kg/ha	P as P_2O_5	108		26	
			ppm of P	21		5	
	PHOSPHORUS OLSEN	kg/ha	P as P_2O_5				
			ppm of P				
EXCHANGEABLE CATIONS	CALCIUM*	kg/ha		3929		2419	
		ppm		1754		1080	
	MAGNESIUM*	kg/ha		1510		1142	
		ppm		674		510	
	POTASSIUM*	kg/ha		1465		874	
		ppm		654		390	
	SODIUM*	kg/ha		405		388	
		ppm		181		173	
	ALUMINUM (KCl Ext.)	kg/ha		2			
		ppm		< 1		< 1	
BASE SATURATION PERCENT							
Calcium	%			45.77		42.39	
Magnesium	%			29.31		33.36	
Potassium	%			8.75		7.85	
Sodium	%			4.11		5.90	
Aluminum	%			0.06		0.00	
Hydrogen	%			12.00		10.50	
EXTRACTABLE MINORS							
Boron* (ppm)				0.83		0.64	
Iron* (ppm)				89		122	
Manganese* (ppm)				155		189	
Copper* (ppm)				9.37		10.85	
Zinc* (ppm)				1.93		0.76	
Aluminum* (ppm)				508		559	
OTHER TESTS	Soluble Salts (mmhos/cm)						
	Chlorides (ppm)						
	NO_3-N (ppm)			76.1		4.4	
	NH_4-N (ppm)			1.7		1.6	
	Total Acidity (ME/100 g)			0		1.676	

* Mehlich III Extractable

The above test results in October 2015, from the initial Soil Fertility tests (S007) three months after installation, showed positive trends in the availability of nutrients but not soil health. This is likely due to the negative impact of the nitrogen topdressing which was applied on the ratoon crop, which reduces Soil Health Score parameters. Overall Soil Health Scores were 4 and 9.7 for treated versus untreated soils, so it appeared the treated lands were inherently worse off from the beginning.

These results show the same outcome.

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Report Date:
15th October,2015

Soil Health Analysis Report

Lab Number		1
Sample Location		MKUZE
Sample ID 1		PCT-T
Sample ID 2		0

NPK

Total Available N (kg/ha)		123
Available Inorganic N (kg/ha)		118
Available Organic N (kg/ha)		5
Value of N Saved	R	-
Total Available P as P (kg/ha)		39
Available Inorganic P as P (kg/ha)		39
Availlable Organic P as P (kg/ha)		0
Available Potassium as K (kg/ha)		446
NPK Value as R/ha	R	-

Soil Health Results

Respiration (Solvita CO2-C) (ppm)		11,7
Water Extractable Organic Carbon (ppm)		194,7
Water Extractable Organic Nitrogen (ppm		9,1
Organic C:N		21,4
Organic N:P		1,2
% Microbially Active Carbon		6,0
Soil Health Calculation		4,0
Cover Crop Mix	10% Legume 90% Grass	

Secondary and Minor Nutrients (H3A Extractable)

Calcium (kg/ha)	1095	
Magnesium (kg/ha)	549	
Sodium (kg/ha)	296	
Sulfur (ppm)	20	14 - 20
Boron (ppm)	0,90	0.7 - 2.6
Iron (ppm)	96	13 - 40+
Manganese (ppm)	35	4 - 6 (15 in RR)
Aluminum (ppm)	190	
Copper (ppm)	1,39	0.5 - 1
Zinc (ppm)	0,93	1 - 3
Calcium+Magnesium/Aluminum	3,86	
Ca:Mg	2,00	
% P Saturation Iron + Aluminum	6,15	
% P Saturation Calcium	3,60	
Plant Effective CEC (meq/100 g)	6,27	
Ca Need (kg/ha)	814	
Ca % for Plant Effective CEC	39,0	

If Ca:Mg ratio is less than 4.5, apply Calcitic lime.
If Ca:Mg ratio is greater than 8, apply Dolomitic lime.
If Ca+Mg/Al is greater than 1.7, and Ca:Mg is less than 4.5, then apply Gypsum.

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Pietermaritzburg, 3201.
Tel: Cel 071 562 7684
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Report Date:
15th October,2015

Soil Health Analysis Report

Lab Number		2
Sample Location		MKUZE
Sample ID 1		PC-UT
Sample ID 2		0

NPK

Total Available N (kg/ha)		39
Available Inorganic N (kg/ha)		2
Available Organic N (kg/ha)		36
Value of N Saved	R	-
Total Available P as P (kg/ha)		49
Available Inorganic P as P (kg/ha)		32
Availllable Organic P as P (kg/ha)		16
Available Potassium as K (kg/ha)		354
NPK Value as R/ha	R	-

Soil Health Results

Respiration (Solvita CO2-C) (ppm)		47,8
Water Extractable Organic Carbon (ppm)		266,9
Water Extractable Organic Nitrogen (ppm		22,6
Organic C:N		11,8
Organic N:P		6,1
% Microbially Active Carbon		17,9
Soil Health Calculation		9,7
Cover Crop Mix	50% Legume 50% Grass	

Secondary and Minor Nutrients (H3A Extractable)

Calcium (kg/ha)	914	
Magnesium (kg/ha)	459	
Sodium (kg/ha)	372	
Sulfur (ppm)	14	14 - 20
Boron (ppm)	0,65	0.7 - 2.6
Iron (ppm)	131	13 - 40+
Manganese (ppm)	70	4 - 6 (15 in RR)
Aluminum (ppm)	173	
Copper (ppm)	3,37	0.5 - 1
Zinc (ppm)	0,69	1 - 3
Calcium+Magnesium/Aluminum	3,54	
Ca:Mg	1,99	
% P Saturation Iron + Aluminum	4,70	
% P Saturation Calcium	3,50	
Plant Effective CEC (meq/100 g)	5,51	
Ca Need (kg/ha)	765	
Ca % for Plant Effective CEC	37,0	

If Ca:Mg ratio is less than 4.5, apply Calcitic lime.
If Ca:Mg ratio is greater than 8, apply Dolomitic lime.
If Ca+Mg/Al is greater than 1.7, and Ca:Mg is less than 4.5, then apply Gypsum.

Comparison of Nutrient availability between Treated vs Untreated trial areas

15th October,2015

TREATED

Available Nutrients: Kg/ha

N	P	K
123	39	446

NUTRIENT ANALYSIS - H3A extraction

Element	Units	Level found
Nitrate N	ppm	118
Ammonium N	ppm	5
Total Inorganic N	ppm	118
Estimated Biological N	kg/ha	5
Estimated TOTAL N	kg/ha	123
Phosphate	ppm	39
Potassium	ppm	446
Calcium	kg/ha	1095
Magnesium	kg/ha	549
Sodium	kg/ha	296
Sulphur	ppm	20
Boron	ppm	.9
Iron	ppm	96
Manganese	ppm	35
Copper	ppm	1.39
Zinc	ppm	.93
*PECEC		6.27

Soil Health Factors	Value	Ranking
Solvita CO2 Burst	11.7	Low
*WEOC (ppm)	194.7	Low
*WEON (ppm)	9.1	Low
C:N Ratio	21.4	High

UNTREATED

Available Nutrients: Kg/ha

N	P	K
39	10	126

NUTRIENT ANALYSIS - H3A extraction

Element	Units	Level found
Nitrate N	ppm	2
Ammonium N	ppm	36
Total Inorganic N	ppm	2
Estimated Biological N	kg/ha	36
Estimated TOTAL N	kg/ha	38
Phosphate	ppm	49
Potassium	ppm	354
Calcium	kg/ha	914
Magnesium	kg/ha	459
Sodium	kg/ha	372
Sulphur	ppm	14
Boron	ppm	.65
Iron	ppm	131
Manganese	ppm	70
Copper	ppm	3.37
Zinc	ppm	.69
*PECEC		5.51

Soil Health Factors	Value	Ranking
Solvita CO2 Burst	39	Medium
*WEOC (ppm)	266.9	Medium
*WEON (ppm)	22.6	Medium
C:N Ratio	11.8	Optimum

A final Soil Health Test was done on the 2nd June, 2016 just before the cane was harvested. The irrigation was already turned off on the treated area but was still running on the untreated area. This was because the crop ripeness of the treated area was better. The cane was harvested a week later on the treated area. The untreated area will be cut 6 weeks later. See picture below.

Treated Cane on the 2nd June, 2016 at time of soil sampling.

kg/ha

BROOKSIDE LABORATORIES, INC. 74362-7

SOIL AUDIT AND INVENTORY REPORT

Name _____ City George State KZN

Independent Consultant Eco - Agri Consultants CC Date 2016/06/08

Sample Location				PCT-T	PC-UT			
Sample Identification								
Lab Number				0759-1	0760-1			
Total Exchange Capacity (ME/100 g)				22.74	17.38			
pH	Buffer (SMP/Sikora)			7.0	7.0			
	H_2O (1:1)			5.9	6.1			
Organic Matter (humus) %				4.25	4.12			
ANIONS	SOLUBLE SULFUR*		ppm	20	14			
	PHOSPHORUS MEHLICH III	kg/ha	P as P_2O_5	72	15			
			ppm of P	14	3			
	BRAY II	kg/ha	P as P_2O_5	108	10			
			ppm of P	21	2			
	OLSEN	kg/ha	P as P_2O_5					
			ppm of P					
EXCHANGEABLE CATIONS	CALCIUM*	kg/ha		4442	3017			
		ppm		1983	1347			
	MAGNESIUM*	kg/ha		1626	1539			
		ppm		726	687			
	POTASSIUM*	kg/ha		1779	818			
		ppm		794	365			
	SODIUM*	kg/ha		334	840			
		ppm		149	375			
	ALUMINUM (KCl Ext.)	kg/ha			2			
		ppm		< 1	< 1			
BASE SATURATION PERCENT								
Calcium	%			43.60	38.75			
Magnesium	%			26.61	32.94			
Potassium	%			8.95	5.38			
Sodium	%			2.85	9.38			
Aluminum	%			0.00	0.06			
Hydrogen	%			18.00	13.50			
EXTRACTABLE MINORS								
Boron* (ppm)				0.84	0.75			
Iron* (ppm)				109	121			
Manganese* (ppm)				210	178			
Copper* (ppm)				13.45	12.93			
Zinc* (ppm)				1.86	0.75			
Aluminum* (ppm)				731	723			
OTHER TESTS	Soluble Salts (mmhos/cm)							
	Chlorides (ppm)							
	NO_3-N (ppm)			27.7	5.1			
	NH_4-N (ppm)			2.5	2.9			
	Total Acidity (ME/100 g)			0	0			
	Carbon (%)			2.00	2.13			

* Mehlich III Extractable

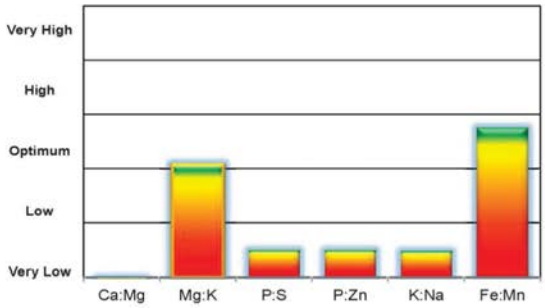
SOIL HEALTH AND FERTILITY REPORT

eco-agri
NATURE'S PARTNER FOR LIFE

Client
Farm Name
Sample Id TREATED
Date 10th June, 2016

BROOKSIDE LABORATORIES INC. – AGRICULTURE - SPORTS TURF - ENVIRONMENTAL – EST. 1951

Soil Health Factors	Value	Ranking
Solvita CO2 Burst	68.7	Medium
*WEOC (ppm)	147.6	Low
*WEON (ppm)	22.9	High
C:N Ratio	6.4	Optimum



10.6

Available Nutrients: Kg/ha

N	P	K
131	22	372

NUTRIENT ANALYSIS - H3A extraction

Element	Units	Level found
Nitrate N	ppm	15.3
Ammonium N	ppm	.5
Total Inorganic N	ppm	16
Estimated Biological N	kg/ha	96
Estimated TOTAL N	kg/ha	131
Phosphate	ppm	22
Potassium	ppm	372
Calcium	kg/ha	257.6
Magnesium	kg/ha	351.68
Sodium	kg/ha	185.92
Sulphur	ppm	17
Boron	ppm	.74
Iron	ppm	287
Manganese	ppm	31
Copper	ppm	2.96
Zinc	ppm	.7
*PECEC		3.99

Ca:Mg	Ca+Mg/Al	Ca%	Mg%
.73	.79	14.4	19.7

RECOMMENDATIONS:
Suggested Cover Crop Blend:
40% legume, 60% grass

Estimated Calcium requirement (kg/ha)

958

Notes:
*WEOC is Water Extractable Organic Carbon
*WEON is Water Extractable Organic Nitrogen
*PECEC is Plant Effective CEC calculated using H3A extractant
If Ca:Mg is less than 4.5, apply Calcitic Lime.
If Ca:Mg is greater than 8, apply Dolomitic Lime
If Ca+Mg/Al is greater than 1.7, and Ca:Mg is less than 4.5, apply Gypsum

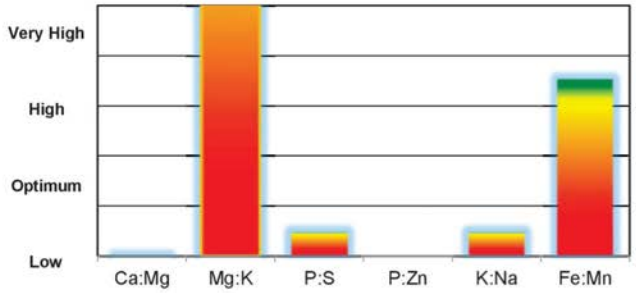
SOIL HEALTH AND FERTILITY REPORT

eco-agri
NATURE'S PARTNER FOR LIFE

Client
Farm Name
Sample Id UNTREATED
Date 10th June, 2016

AGRICULTURE - SPORTS TURF - ENVIRONMENTAL
BROOKSIDE LABORATORIES INC. EST. 1991

Soil Health Factors	Value	Ranking
Solvita CO2 Burst	41.5	Medium
*WEOC (ppm)	160.5	Medium
*WEON (ppm)	17.7	Medium
C:N Ratio	9.1	Optimum



7,52

Available Nutrients: Kg/ha

N	P	K
43	10	126

NUTRIENT ANALYSIS - H3A extraction

Element	Units	Level found
Nitrate N	ppm	.6
Ammonium N	ppm	.5
Total Inorganic N	ppm	1
Estimated Biological N	kg/ha	41
Estimated TOTAL N	kg/ha	43
Phosphate	ppm	10
Potassium	ppm	126
Calcium	kg/ha	165.76
Magnesium	kg/ha	259.84
Sodium	kg/ha	421.12
Sulphur	ppm	9
Boron	ppm	.47
Iron	ppm	245
Manganese	ppm	21
Copper	ppm	3.03
Zinc	ppm	0
*PECEC		3.39

Ca:Mg	Ca+Mg/Al	Ca%	Mg%
.64	.65	10.9	17.1

RECOMMENDATIONS:
Suggested Cover Crop Blend:
50% legume, 50% grass.

Estimated Calcium requirement (kg/ha)

866

Notes:
*WEOC is Water Extractable Organic Carbon
*WEON is Water Extractable Organic Nitrogen
*PECEC is Plant Effective CEC calculated using H3A extractant
If Ca:Mg is less than 4.5, apply Calcitic Lime.
If Ca:Mg is greater than 8, apply Dolomitic Lime
If Ca+Mg/Al is greater than 1.7, and Ca:Mg is less than 4.5, apply Gypsum

Comparison of Nutrient availability between Treated vs Untreated trial areas

10th June,2016

TREATED

Available Nutrients: Kg/ha

N	P	K
131	22	372

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*WEOC (ppm)	147.6	Low
*WEON (ppm)	22.9	High
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UNTREATED

Available Nutrients: Kg/ha

N	P	K
43	10	126

NUTRIENT ANALYSIS - H3A extraction

Element	Units	Level found
Nitrate N	ppm	.6
Ammonium N	ppm	.5
Total Inorganic N	ppm	1
Estimated Biological N	kg/ha	41
Estimated TOTAL N	kg/ha	43
Phosphate	ppm	10
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Solvita CO2 Burst	41.5	Medium
*WEOC (ppm)	160.5	Medium
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C:N Ratio	9.1	Optimum

The same trends are seen in the Soil Fertility tests (S007) shown above for these trial areas.

The pH was reduced, the Ca:Mg ratio improved and sodium at this particular site was greatly reduced. Some of this effects may be site specific due to a leaking pipe in the untreated area which may have raised the sodium level, but this is a common trend.

It is very important to remember that sodium, magnesium and potassium can substantially influence pH (sometimes more so than calcium), thus an excess of these cations could accompany an elevated pH. However, a large calcium deficiency was still present.

What has occurred in this case, is that the sodium levels were greatly reduced, magnesium to a lesser extent, calcium increased and soil pH was lowered.

The availability of most nutrients was greatly enhanced, especially in the case of potassium which appears to have been previously tightly held in the magnesium dense clay lattice.

It was also pleasing to see the increase in the availability of phosphate, sulphur and trace elements due to the enhanced biological activity and soil health.

My earlier observations regarding the effects of higher nitrogen levels in the Soil Health Tests in the treated area, remained the same. The Water Extractable Organic Carbon level was lower due to it having been consumed by the soil biome and converted to organic nitrogen.

The Soil Health Scores summarised all the above improvements with the Rainmaker treated lands scoring 10.6, while the untreated lands scored 7.52.

It was notable that Soil Health Scores were previously 4 and 9.7 for treated versus untreated soils. After nine months of Rainmaker treatment, they were the other way round with treated lands at 10.6 and untreated at 7.52. The treated lands improved while the untreated lands regressed.

Leaf Analysis at the end of trial period

BROOKSIDE LABORATORIES, INC.

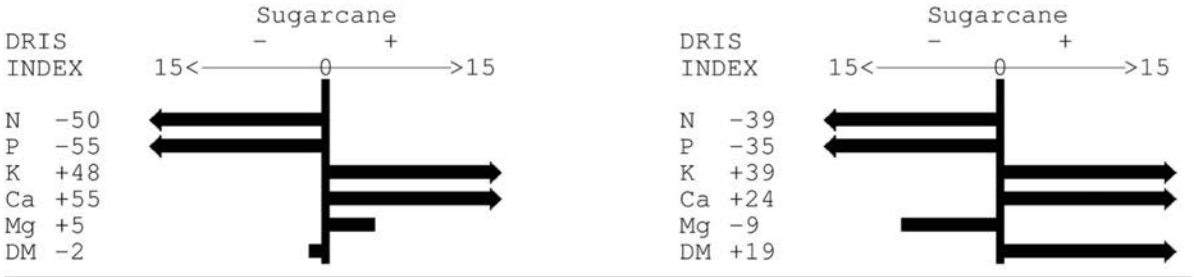
** PLANT TISSUE ANALYSIS **

File Number: 74362
Date Received: 2016/06/07
Date Reported: 2016/06/08

Submitted By: Eco - Agri Consultants CC

Lab Number		5398			5399
Location		Mkuze			Mkuze
Description		Kortplaas Treated			Kortplaas Un-treated
Plant Part		Leaves/Upper			Leaves/Upper
PERCENTAGES (%)					
NITROGEN	(N)	0.98	NITROGEN	(N)	0.78
PHOSPHORUS	(P)	0.117	PHOSPHORUS	(P)	0.101
POTASSIUM	(K)	1.95	POTASSIUM	(K)	1.39
CALCIUM	(Ca)	0.45	CALCIUM	(Ca)	0.23
MAGNESIUM	(Mg)	0.217	MAGNESIUM	(Mg)	0.122
SULFUR	(S)	0.167	SULFUR	(S)	0.134
PARTS/MILLION (ppm)					
BORON	(B)	6.4	BORON	(B)	4.2
IRON	(Fe)	1300.0	IRON	(Fe)	284.0
MANGANESE	(Mn)	51.9	MANGANESE	(Mn)	50.4
COPPER	(Cu)	15.4	COPPER	(Cu)	7.2
ZINC	(Zn)	16.8	ZINC	(Zn)	13.1
ALUMINUM	(Al)	1120.0	ALUMINUM	(Al)	346.0
SODIUM	(Na)	175.0	SODIUM	(Na)	175.0

DRIS INTERPRETATION



The above leaf test results reflect nutrient levels following a similar trend to those found in the soil and were very notable. All macro and micro nutrients, except for Na, were increased across the board.

Conclusion

By observing the visible condition of the soil and the cane crop over a growing season, there was undeniable evidence that the Rainmaker water treatment system had a large beneficial impact on the soil biome, soil structure and the crop.

Circumstances were difficult to say the least, with a very dry season experienced.

Greatly improved soil structure and root penetration was experienced even though the water quality was relatively good with low sodium and chloride levels. High pH and high bicarbonate levels were the only problems evident.

Even though the soil of the trial area had very low calcium and high magnesium levels, showing that these soils are naturally compact and of poor structure, the Rainmaker water treatment still had a large positive influence on the soil biome and resultant soil health.

The improved soil structure would have greatly enhanced the moisture infiltration and retention capacity of the soil, while the enhanced root system would have greatly improved the uptake of water and available nutrients leading to increased plant growth.

The enhanced soil structure would have greatly improved the exchange of oxygen and carbon dioxide, allowing for improved soil respiration.

This is borne out by the greatly increased Soil Health Scores in the treated areas, as well as much improved nitrogen generation by biological activity.

Other information can also be extracted from the soil test results (S007 & S019) giving further insight into the reasons for the positive soil responses, as the whole process becomes better understood.

These initial trial results are most encouraging.