NUTRIENT UPTAKE AND LEACHING AFTER IRRIGATING BANANA (*MUSA ACUMINATA*) AND TARO (*COLACASIA ESCULENTUM*) WITH DEWATS EFFLUENT

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WISA 2016 Water Institute of Southern Africa DURBAN, SOUTH AFRICA Water - The ultimate constraint

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WATER RESEARCH COMMISSION

Structure

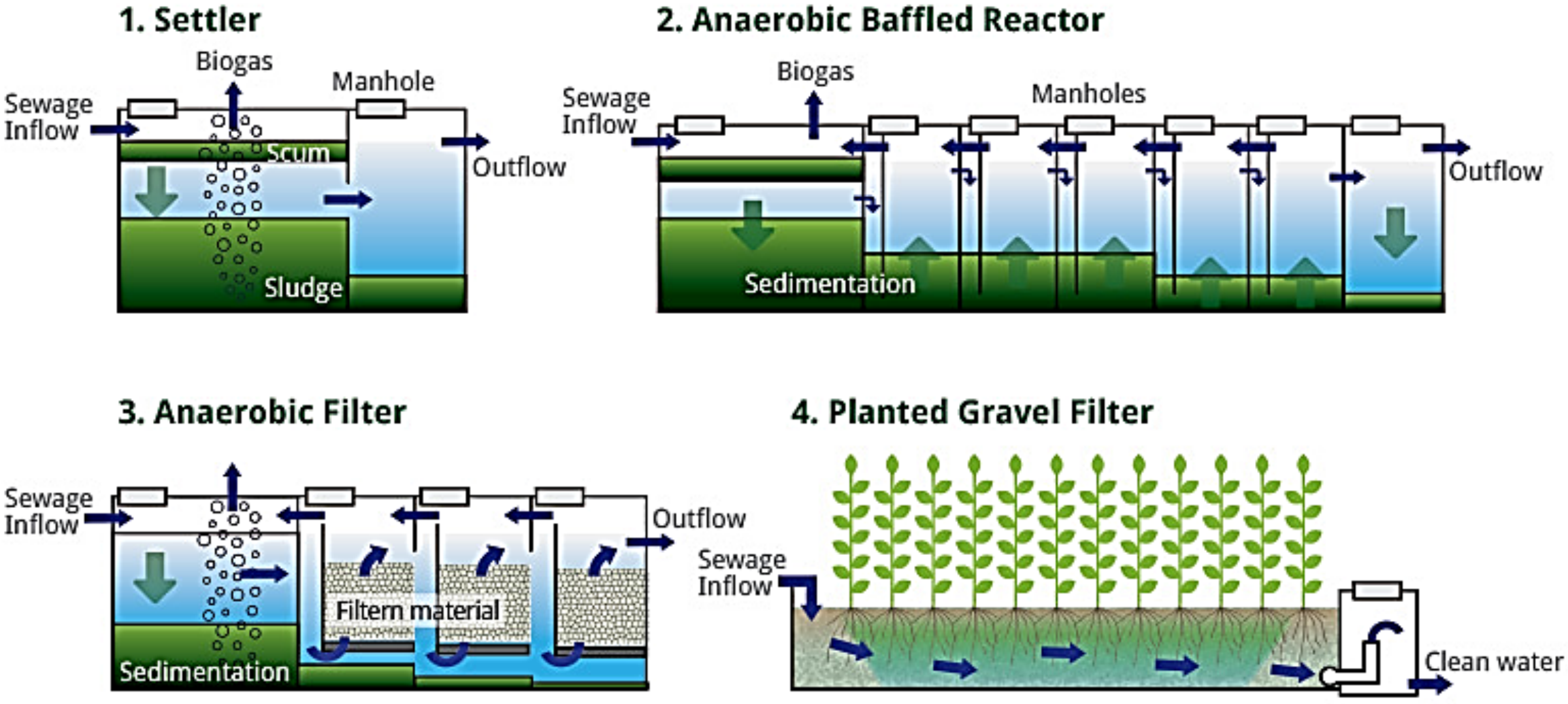
1. Introduction
2. Problem statement
3. Materials and Methods
4. Results and discussion
5. Conclusions
6. Recommendations
7. Acknowledgements

Introduction

- Informal settlements
  - Lack proper sanitation
  - Low cost sanitation technologies required
    - VIP toilets
    - UD toilets
    - Water borne - **preferred**

    Not preferred
- DEWATS (Decentralised Wastewater Treatment System)
  - Water borne
  - Energy not required
  - Robust

Decentralised Wastewater Treatment system: DEWATS



Courtesy of BORDA, Germany

Problem statement

- Disposal of effluent - Rivers
  - Eutrophication
- Agricultural use
  - Nutrient (N and P) retained in soil
  - Plants take up nutrients
  - Some leached
  - No information
    - Land required / household (different crops)
    - Effluent management – seasons
    - Environmental risks

} water and nutrient mass balances

Objectives of the study:

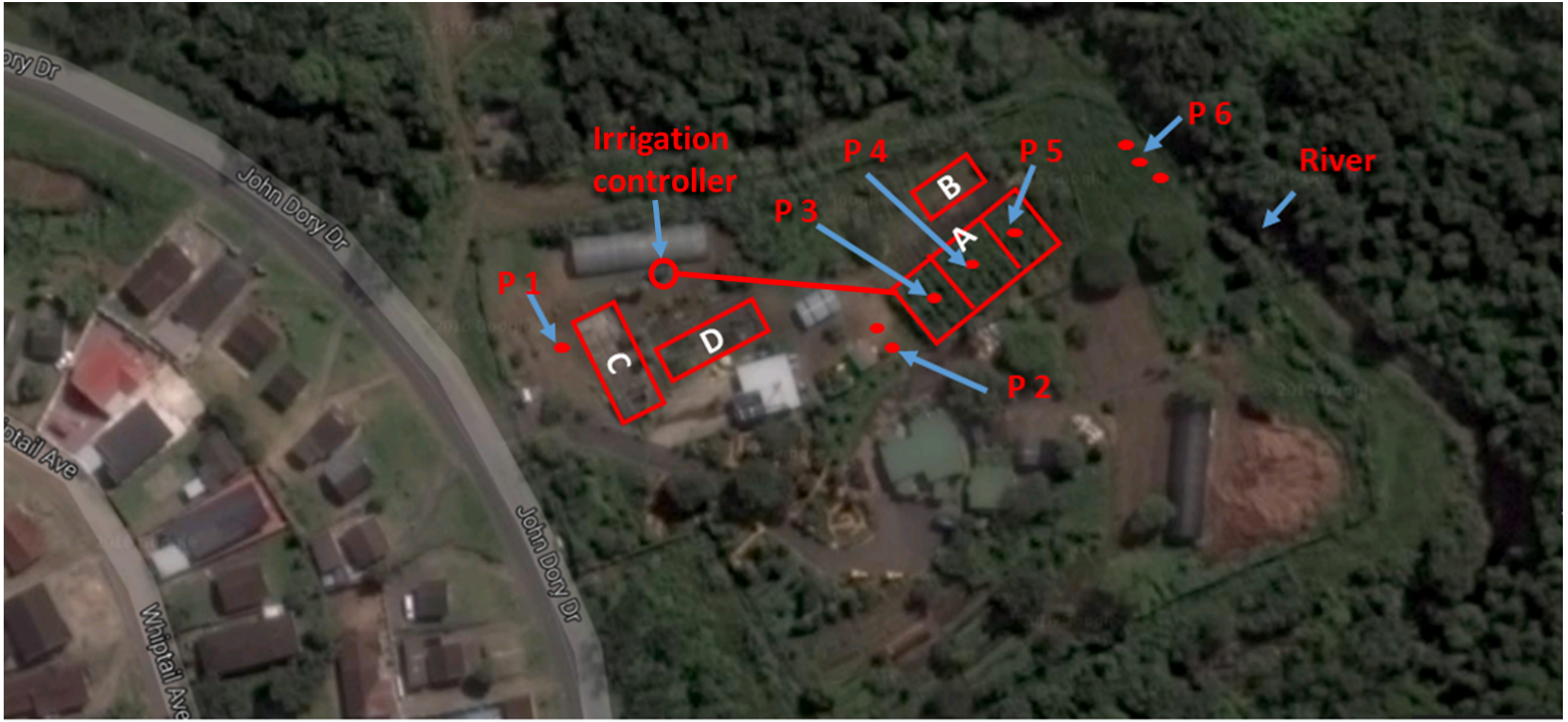
To investigate the effect of irrigating Banana and Taro with DEWATS effluent on:

1. Soil chemical properties,
2. Crop growth,
3. Nutrient uptake and,
4. Nutrient leaching

N.B. Data collected used as models parameters.

MATERIALS AND METHODS

Experimental site



Key:

A = Field; B = Weather station; C = DEWATS; D = Wetlands; P = Piezometer

Experimental material

- DEWATS effluent
  - Second wetlands
- Banana
  - Williams Variety- Tissue cultured
- Taro
  - Dumbe lomfula (local)- Suckers

Experimental design

2 treatments

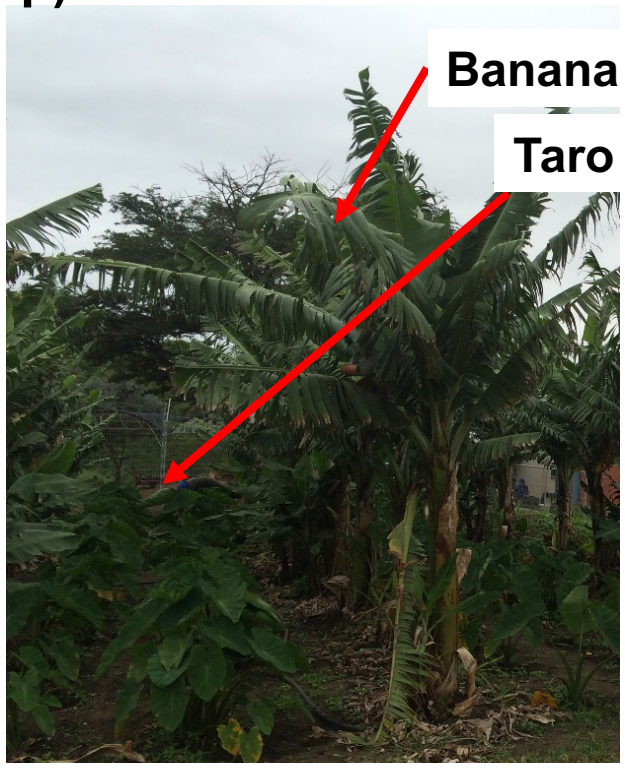
- Tap water irrigation + fertilizer **(TW)**
- DEWATS effluent irrigation + no fertiliser **(DE)**

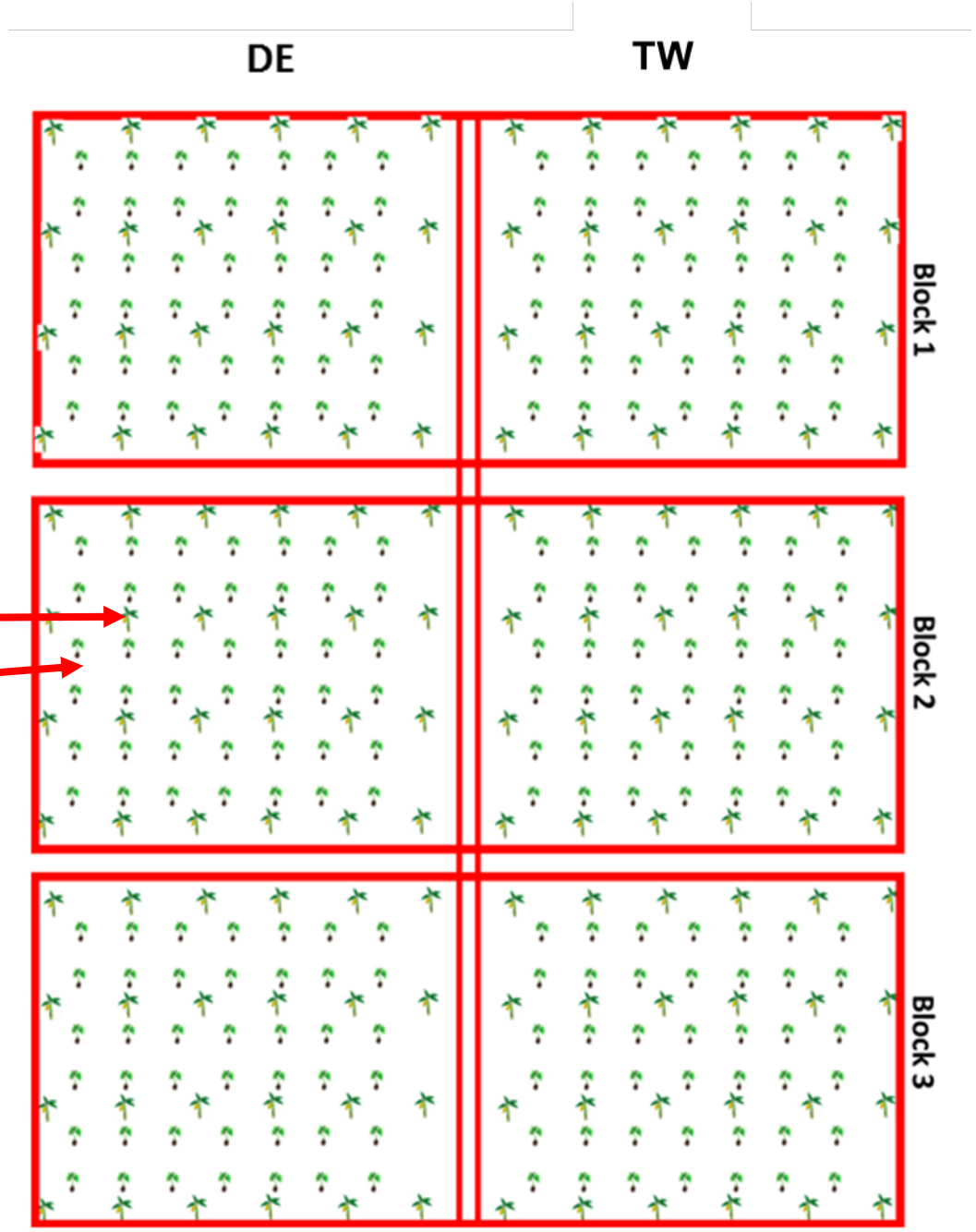
2 crops (Intercrop)

- Banana
- Taro

Design

- RCBD





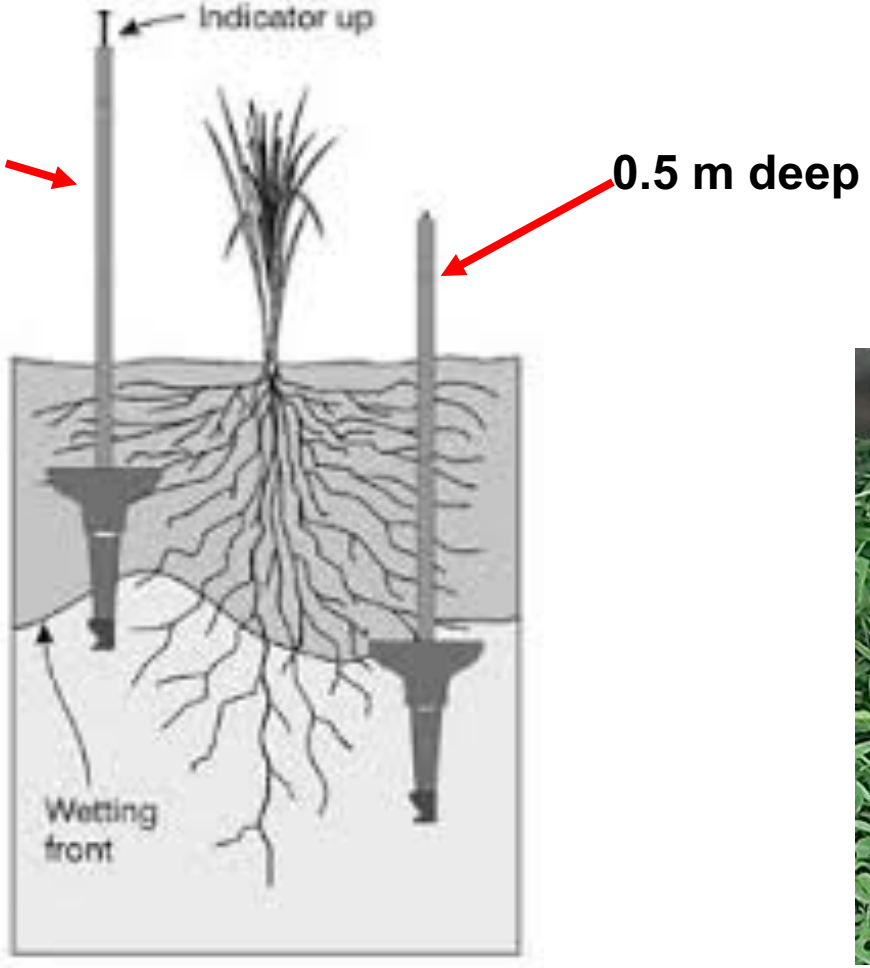
Experimental methods

- **Planting**
  - Banana (3 m x 1.5 m)
  - Taro (1 m x 1 m)
- **Crop management**
  - Fertiliser application, weeding etc
  - Irrigation
    - 8 ℓ $plant^{-1}$ day^{-1}
    - Soil moisture - CS 650 soil water content reflectometers (Campbell Scientific, INC.)

CS 650 soil water content reflectometers

Collection of leachates

Wetting Front Detectors (WFDs)



Collection from WFDs

Piezometer installed 1 m deep

Laboratory analyses

- **DEWATS effluent**
  - Mineral N (NH_4^+-N and NO_3^--N), PO_4^{3-}-P, Chemical Oxygen Demand (COD), Total solids and Coliforms (APHA, 2000)
- **Soil sampling** (3 layers: 0 – 0.3 m, 0.3 – 0.6 m, 0.6 – 0.9 m)
  - Chemical properties:
    - MIR – N, Brays P, NH_4^+-N, NO_3^--N, PO_4^{3-}-P, Total cations, K, Mg, Ca, Zn, Cu, Fe
  - Physical properties:
    - Water retention at – 1 500 and – 33 kPa, soil texture, saturated hydraulic conductivity, bulk density

Plant growth variables

Leaf area index (m^2 m^{-2})

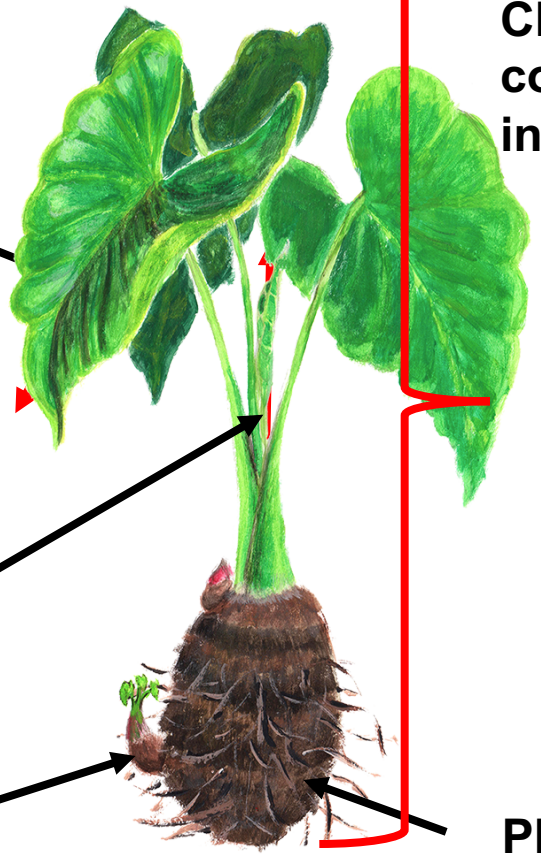
Yield (kg m^{-2})

Plant tissue nutrient analysis mg kg^{-1}

Fresh and dry biomass (kg ha^{-1})

Plant height (m)

Chlorophyll content index



Leaf area index (m^2 m^{-2})

Fresh and dry biomass (kg ha^{-1})

Yield (kg ha^{-1})

Plant tissue nutrient analysis mg kg^{-1}

Data analysis

- Genstat 14th edition (VSN International, Hemel Hempstead, UK).
- Mean separation - Standard error of deviation (SEDs) - 5% significance level.

RESULTS

DEWATS effluent characterisation

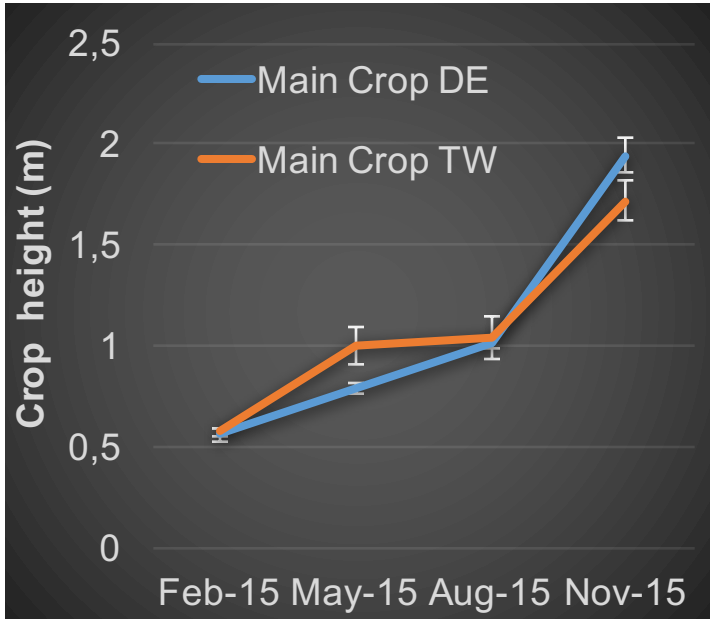
	NH_4^+-N	NO_3^--N	Total-N	PO_4^{3-}-P	SS	COD	pH	EC
	(mg ℓ^{-1})						(-)	(mS m^{-1})
Sample (n)	3	3	6		19	19	19	19
HCW	6.7	12.73	19.43	4.13	4	68	6 to 7	74
SED	1.07	7.86		3	1.4	7.67		2.9
Standard*	-	-	-	10	-	5 000	6 to 9	≤ 200

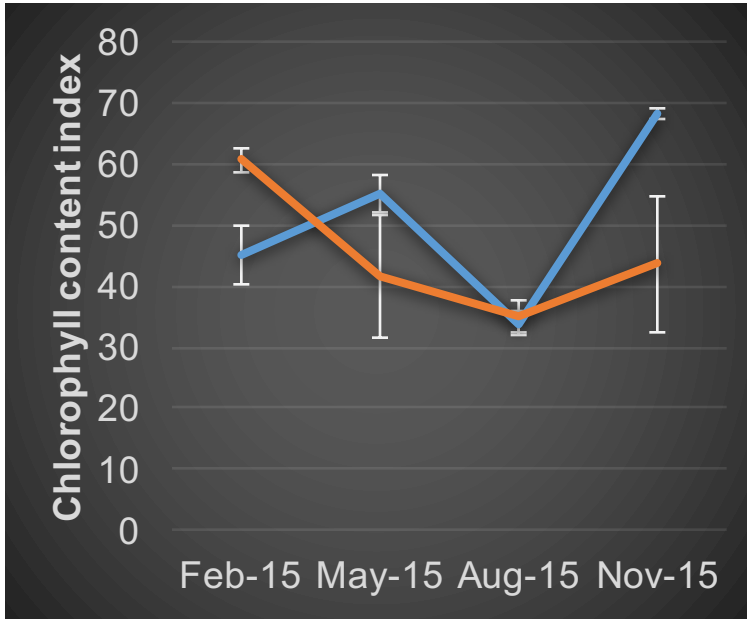
*DWA standards when 50 m^3 of water is used for irrigation per day,

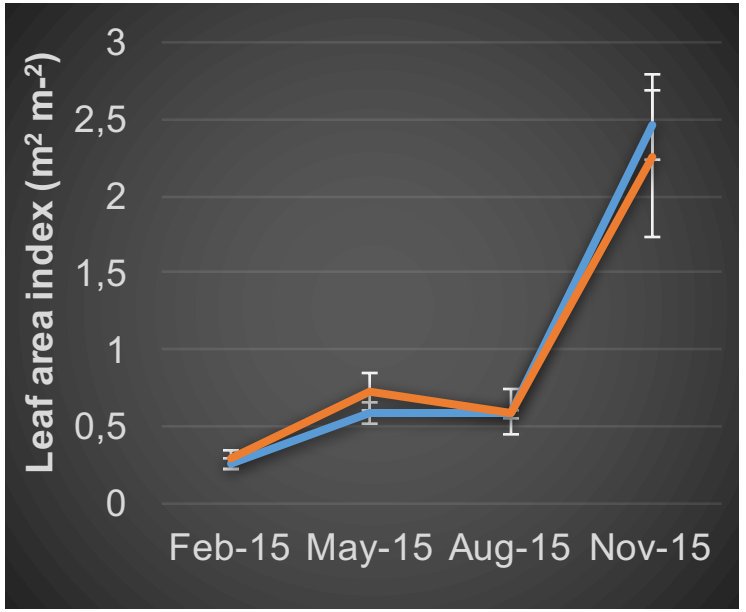
SS = suspended solids, COD = chemical oxygen demand, EC = Electrical conductivity, SED = Standard error of deviation.

Crop growth rate

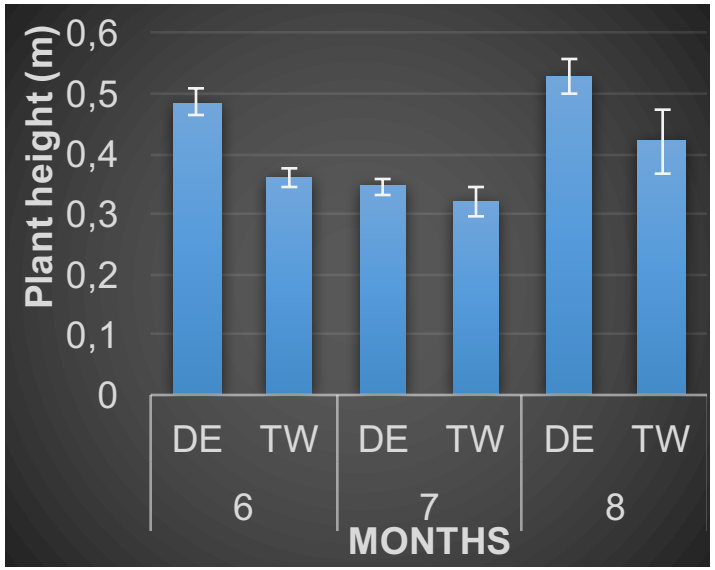
Banana

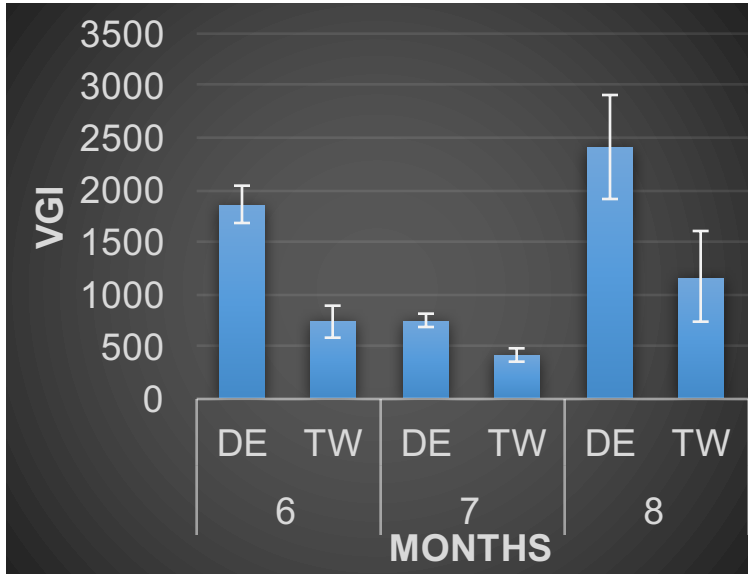


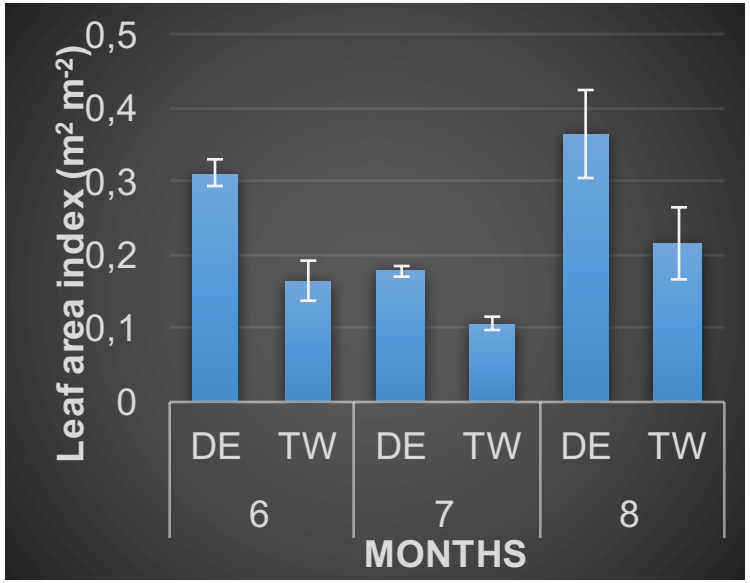




Taro

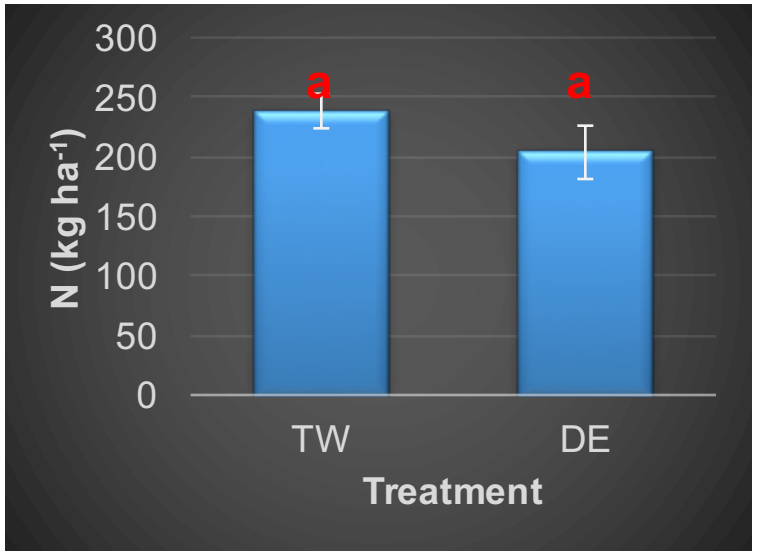


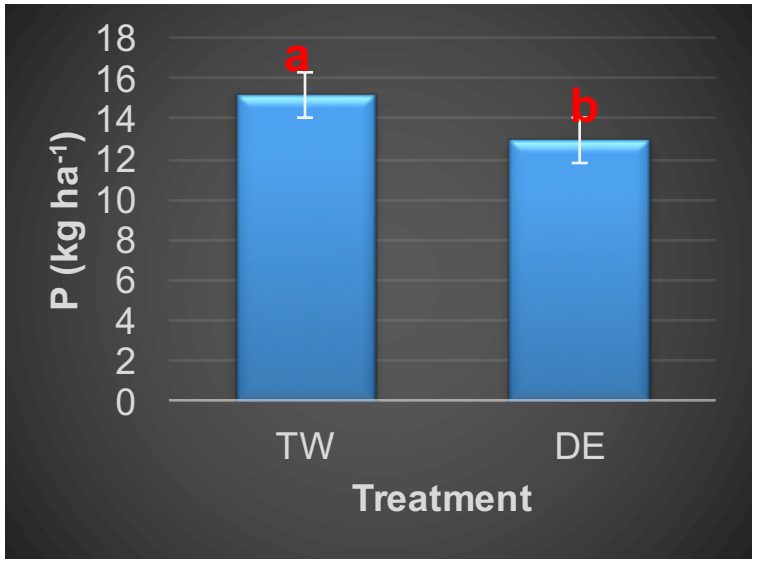




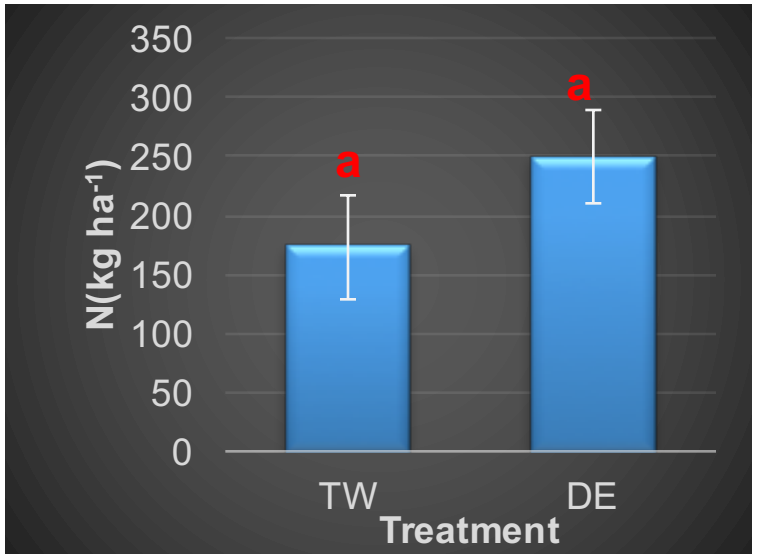
Nutrient (N and P) uptake

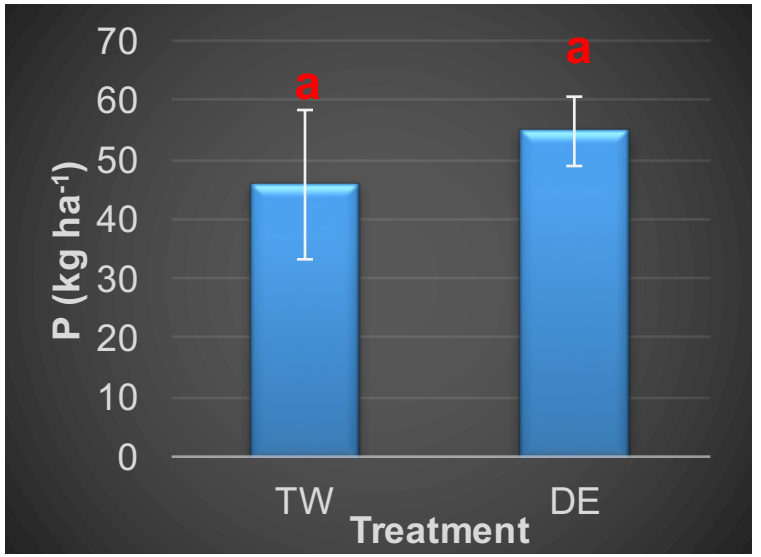
Banana





Taro





Soil N and P

Soil Depth	Treatment	N	SED	P	SED
		(%)		mg kg^{-1}	
0.3 m	DE	0.34^{a}	0.012	52.2^{a}	2
	TW	0.32^{abc}	0.032	72.5^{a}	24.4
0.6 m	DE	0.3^{bc}	0.012	5.2^{b}	0.8
	TW	0.32^{b}	0.003	5.3^{b}	0.5
0.9 m	DE	0.28^{cd}	0.026	5.5^{b}	1.2
	TW	0.29^{c}	0.015	5.3^{b}	1.2

SED = Standard error of deviation (5 % significance level)

Superscripts a, b, c and d denotes means significantly different at 5 % significance level

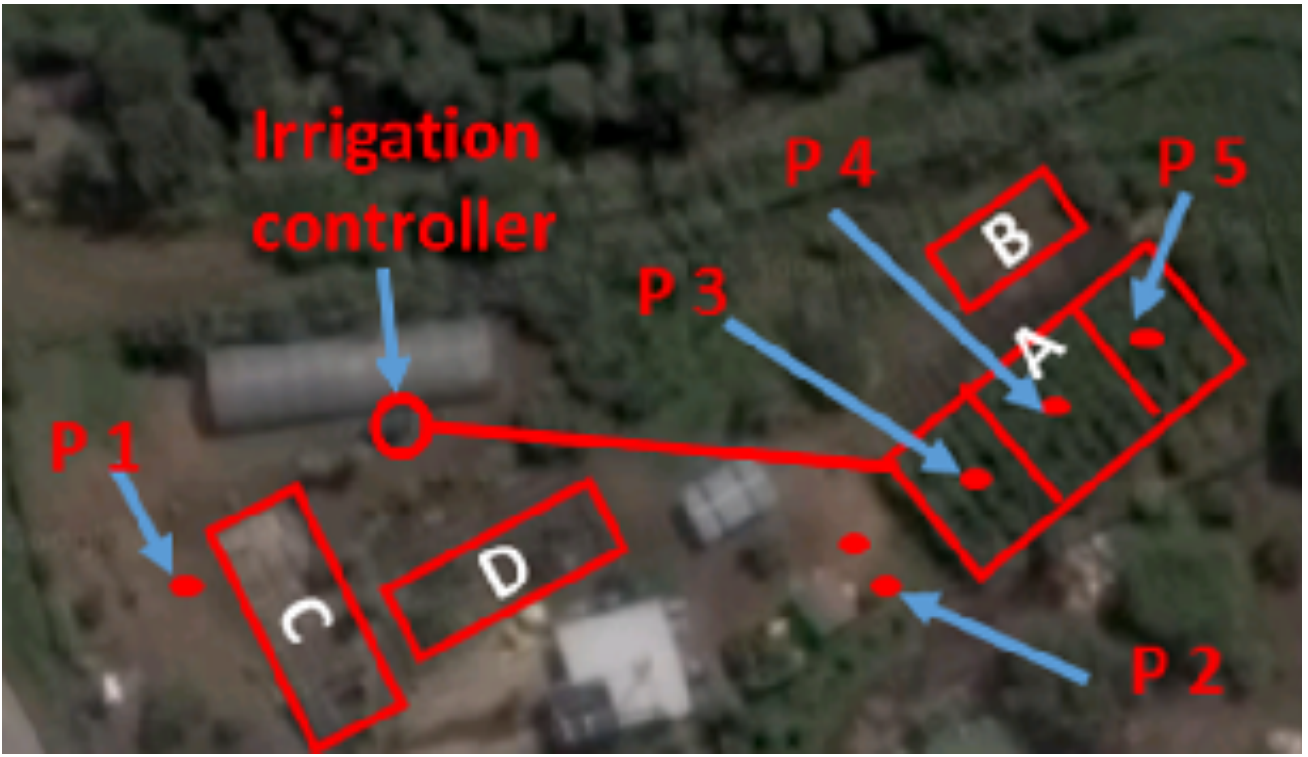
Nutrient leaching

Analysis Of Variance: Mean squares

Source of variation	D.f.	Total-N	NH_4^+-N	NO_3^--N	PO_4^{3-}-P
Block	2	3150	2.9	3031	6.5
Date	8	4 725*	12*	4 696*	2.8*
Depth	1	338	0.4	383	47.1
Treatment	1	16	0.5	11	12.9
Date X Depth	8	248	0.5	250	0.6
Date X Treatment	8	1 300***	7.6*	73***	1.9
Depth X Treatment	1	66	0.3	1 335	3.4
Date X Depth X Treatment	8	194	0.6	190	4.7
Residual	67	496	1.6	480	4.0
Total	104				

Significant difference at 5 % level***, 1 % level**, 0.1 % level*

Leachates: Piezometers vs WFDs



Depth	Treatment	NH_4^+-N	Total N	PO_4^{3-}-P
			mg ℓ^{-1}	
0.3 m	DE	2.1^{b}	7.6^{b}	4.2^{b}
	TW	1.5^{b}	4.4^{c}	4.0^{b}
0.5 m	DE	2.1^{b}	7.2^{b}	5.3^{b}
	TW	1.3^{b}	4.4^{c}	2.5^{b}
1 m	P1	17.4^{a}	19.5^{a}	54.6^{a}
	P2	15.6^{a}	18.1^{a}	4.9^{b}
	P3	1.4^{b}	4.5^{c}	15.4^{b}
	P4	1.4^{b}	6.3^{bc}	5.6^{b}
	P5	2.8^{b}	10.8^{ab}	10.8^{b}

Key:

A = Field; B = Weather station; C = DEWATS; D = Wetlands; P = Piezometer

Superscripts a, b, c and d denotes means significantly different at 5 % significance level

CONCLUSIONS

Conclusions

- **Crop growth**
  - DEWATS effluent increased crop growth for taro.
- **Nutrient uptake**
  - High P uptake in banana TW uptake needs further investigations.
- **Soil chemical properties**
  - High N at 0.3 m (DE).
  - High P at 0.3 m regardless of treatment.
- **Nutrient leaching**
  - No leaching of N and P due to irrigation.

RECOMMENDATIONS

Project status: In progress

- ❑ Agricultural land required / household (Different crops).
- ❑ Management of effluent in different seasons.
- ❑ Environmental risk assessment.
  - Nutrient mass balances
  - Water mass balances
    - Irrigation scheduling model (SWB Scie)- **at field scale.**
    - Nutrient, water and energy flux model (Hydrus 3D)- **Spatial modeling**

Acknowledgements

EThekwini Water and Sanitation