

# ***Recent Developments in Irrigation Practices for Sugarcane Industry***



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# State of the Philippine Sugar Industry

**423,000 has**

80% of farms are 5 has and less

**Php 87 Billion annual contribution to economy**

65,000 farmers, 700,000 workers, 5 M dependents

**59 TC/ha (39 to 76 TC/ha)**

\*Thailand has avg production of 70 TC/ha

**Current cost of production**

**P70-100 k/ha**



# Challenges

- The need to produce more sugar, efficiently, productively at lower cost
- Changing climatic conditions and weather patterns (water is a major limiting factor for productivity)
- The industry expansion depends upon efficient water use in production



# Vision for the Sugarcane Industry 2024



# Sugar Industry Development Act of 2015

Primary goal of SIDA of 2015 is to:

- Promote the competitiveness of the sugarcane industry
- Maximize the utilization of sugarcane resources
- **Improve income of farmers through improved productivity**
- Product diversification
- Job generation
- Increased efficiency of sugar mills



# Boosting the Sugarcane Industry Through Smart Farming Techniques

## Project 1. Smart Water Management Strategies for Sugarcane



Implementing Agency: Central Luzon State University

# Objectives

## **General Objective:**

Increase yield in sugarcane production by 30% through the use of smart-irrigation technologies.

## **Specific Objectives:**

- Provide information on current irrigation status and practices in the sugar industry;
- Develop optimum irrigation scheduling schemes for sugarcane using soil moisture and weather monitoring systems;
- Increase water productivity in sugarcane production under drip and furrow irrigation method

# Baseline Studies on Sugarcane Irrigation Practices

A survey questionnaire was prepared for the conduct of a field survey to determine current irrigation practices in the sugarcane industry.

From 120 respondents from Pampanga , Tarlac, Batangas and Negros Occidental:

Yield Comparison : Comparison between irrigated and non-irrigated sugarcane reveals that there is a 45% to 60% (65 TC/ha to 100TC/ha) increase in yield when sugarcane is irrigated.





# Baseline Studies on Sugarcane Irrigation Practices

## Negros Occidental

83 respondents

Average area 65 has

	No. Of Users
No irrigation	35
Flooding	9
Furrow	29
Drip	5
Sprinkler	10



## Yield Comparison

No irrigation	62.5 TC/ha
With irrigation	80.6 TC/ha

An average of 29% yield increase

Irrigation Cost/ha	Php 9,811
Production cost	Php 77,392

Irrigation Cost as  
% of Production Cost 12.7%

# Flooding

La Granja, Negros Occidental

Water is supplied through quick coupling aluminum pipes or PE pipes, water distribution is through gravity, high labor requirement



# Baseline Studies on Sugarcane Irrigation Practices



Hda. Cabug, Brgy. Cabug, Bacolod City

N 10°35'18.4"

E 122°56'45.0"



# Baseline Studies on Sugarcane Irrigation Practices



ERS Farms, Brgy. Vista Alegre, Bacolod City

N 10°38'21.5"

E 123°00'41.9"

Elevation: 86 m



# Baseline Studies on Sugarcane Irrigation Practices



Had. Sta. Maria Gonzaga, Brgy. Zone 15, Talisay City  
N  $10^{\circ}42'22.3''$   
E  $122^{\circ}59'10.8''$   
Elevation: 31 m

# Baseline Studies on Sugarcane Irrigation Practices



Hda. Igpanulong, Brgy Robles, La Castellana,  
Negros Occidental



Hda. Grande, Brgy Robles, La Castellana, Negros  
Occidental



# Baseline Studies on Sugarcane Irrigation Practices



Hda. Igpanulong, Brgy Robles, La Castellana,  
Negros Occidental



Hda. Tamon, Brgy Lalagsan, La Castellana, Negros  
Occidental

## Irrigation Water Sources

# Hand-held Hose Irrigation

La Carlota City, Negros Occidental  
More efficient than flooding but  
labor-intensive





# Baseline Studies on Sugarcane Irrigation Practices

## Farmer's Innovation



Hda. Najalanan, Brgy Robles, La Castellana, Negros Occidental



Had. Ma. Luisa, Brgy. E. Lopez, Silay City

`Location: 10°48'32.64"N,123°1'38.86"E

# Furrow Irrigation

Furrow irrigation is the most widely used irrigation system for sugarcane in Batangas, Tarlac and Pampanga. It has low equipment costs and is simple to operate.

Mr. Manolito Enriquez  
Brgy. Cugunan, Nasugbu, Batangas  
2 hectares  
5 days of irrigation per ha  
75 TC/ha irrigated  
52 TC/ha non-irrigated





# Furrow Irrigation

Mr. Felix Vidal

Brgy. Balibago, Lian, Batangas

4 hectares

5 days of irrigation per ha

100 TC/ha irrigated

75 TC/ha non-irrigated



# Hand-move Sprinkler

Hda Makina, Silay City, Negros Occidental

150 hectares

100 TC/ha - irrigated,

50 TC/ha – rainfed

Fuel consumption – 30 liters/ha

Capacity - 3 hrs/ha



Maximum application rate should take account of the intake capacity of the soil and the potential for soil erosion.





# Baseline Studies on Sugarcane Irrigation Practices



One disadvantage of a hand-move sprinkler system is the high labor requirement.



# Hand-move Sprinkler

Brgy Guadalupe, San Carlos City,  
Negros Occidental  
74 hectares  
100 TC/ha - irrigated,  
40 TC/ha – rainfed  
Fuel consumption – 12.5 liters/hr  
Capacity - 3 has/day, 5 hrs/ha





# Hand-move Sprinkler Irrigation

Hacienda Logo, Vallehermoso,  
San Carlos City, Negros Occidental  
12 hectares out of 52 hectares  
80 TC/ha - irrigated,  
50 TC/ha – rainfed  
Fuel consumption – 90 liters/day



# Travelling Boom Sprinkler

ECJ Farms

Hacienda Fe, La Carlota City

Capacity 3.5 ha/day,

Consumption 7 liters/hr

Boom width 40 m width

Speed – 60 m/hr

Eqpt Cost Php750,000/unit







# Subsurface Drip Irrigation

Calatrava Sugar Alliance, Villa  
Rosa, Brgy San Isidro, Calatrava,  
San Carlos City, Negros Occidental  
128 hectares irrigated  
100 TC/ha - irrigated,  
55 TC/ha – rainfed  
Netafim – Php130,000/ha, 7 years

Advantages of drip irrigation over sprinkler

1. Manpower reqt (4 vs 8)
2. Fertigation (high fertilizer use efficiency)
3. Low energy requirement





# Surface Drip Irrigation

Hawaiian Philippine Company, Silay City, Negros Occidental





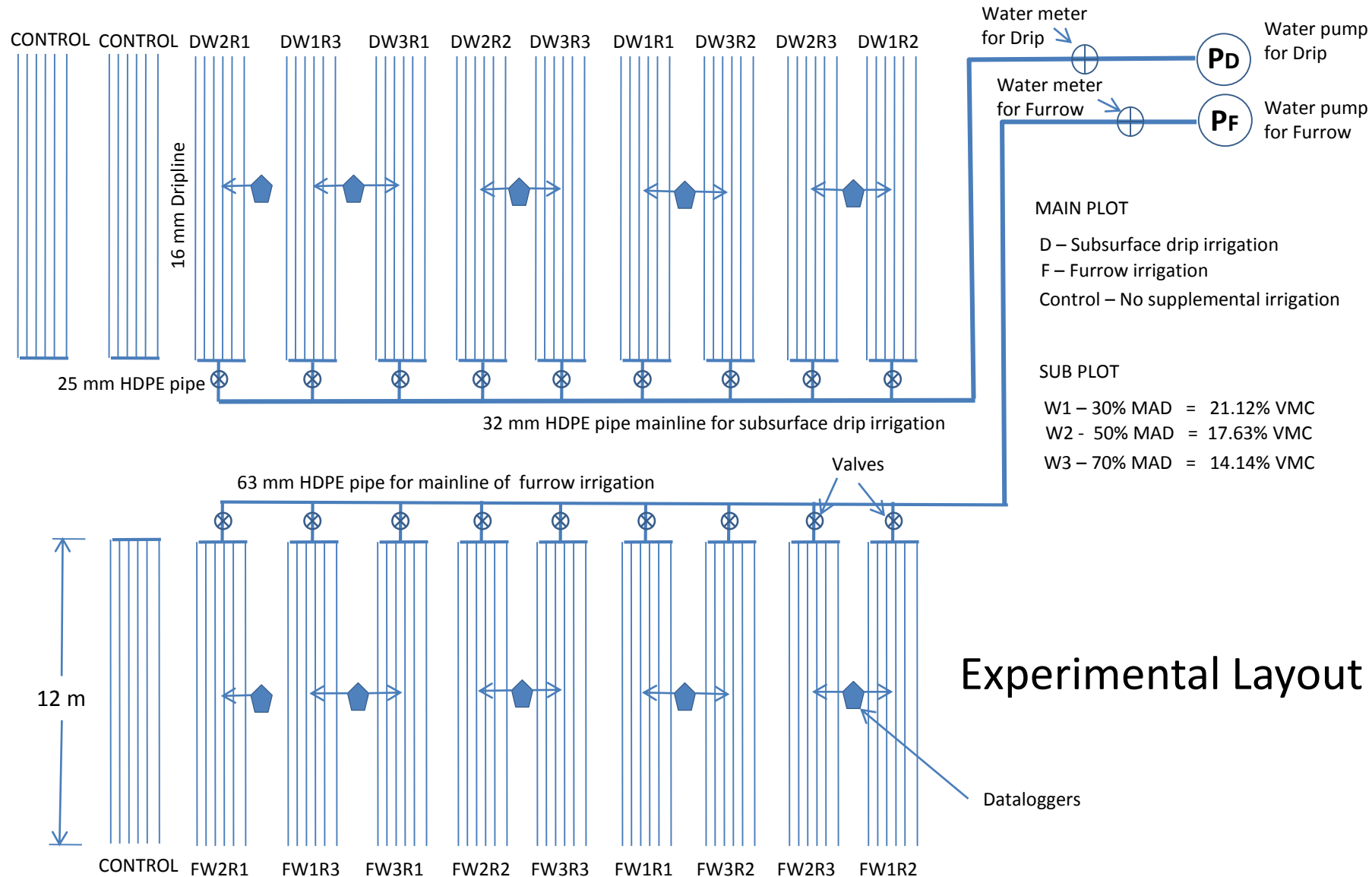
# Sub surface Drip Irrigation

- Netafim Demo Farm
- Agriculto Corp, Paniqui, Tarlac
- 3.6 has, 3 blocks
- Php130,000/ha
- One (1) ha/day
- 23 hrs operation
- Head control unit, 63 mm PE main pipes,
- 16 mm diameter dripline, with a lateral spacing of 1.5 m, emitter spacing of 0.5 m and emitter flow rate 1.0 lph.
- Each crop row is irrigated with one dripline installed at 0.3 m below the soil. Date of installation Dec 2014



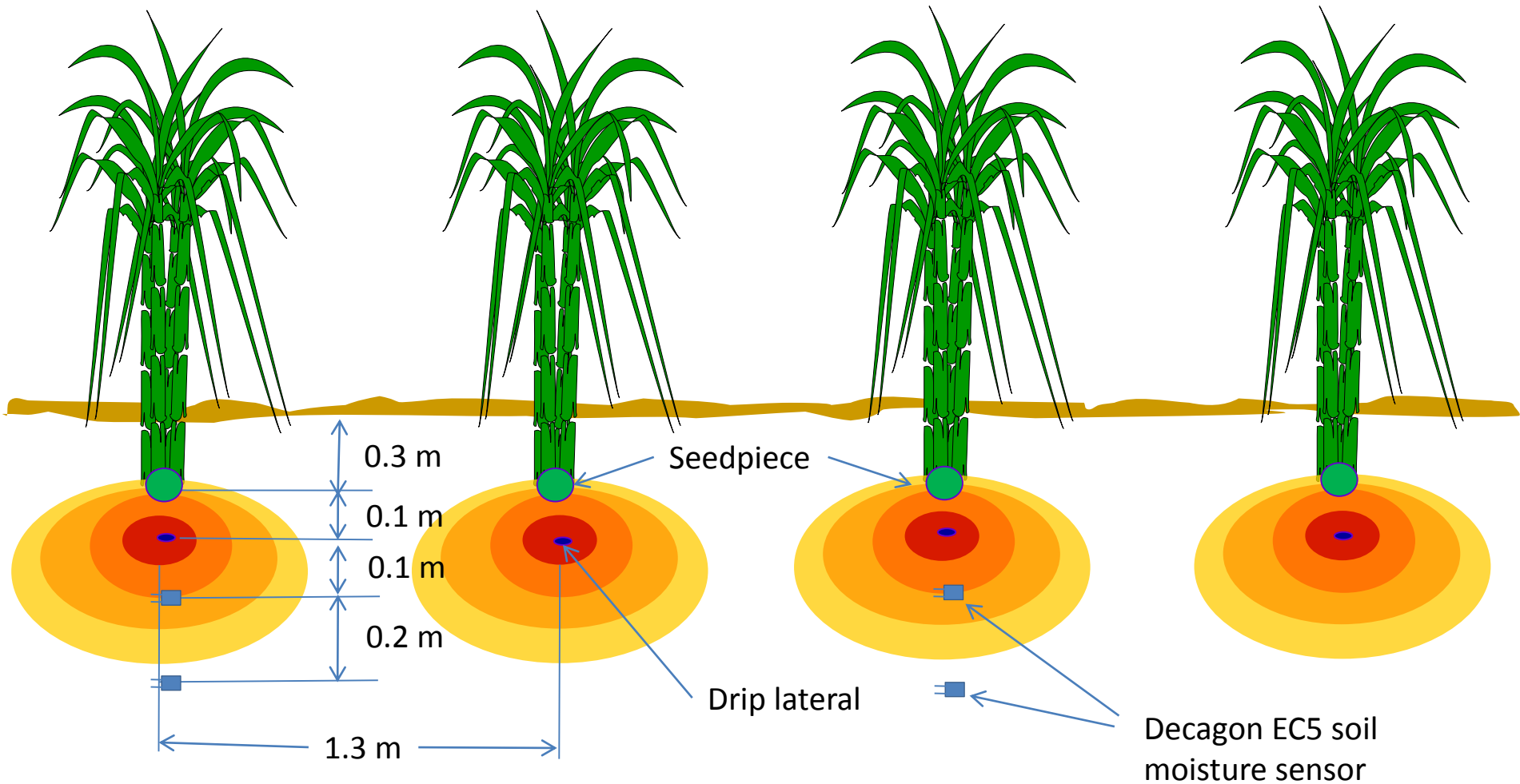
# **Field Experiment on irrigation scheduling schemes for sugarcane**

# Optimization of irrigation scheduling schemes for sugarcane





# Optimization of irrigation scheduling schemes for sugarcane



# Optimization of irrigation scheduling schemes for sugarcane

## Installation of irrigation System



Installation of drip laterals (16 mm, 30 cm spacing, 2 lph TopDrip)



Individual valves for each plot

December 12, 2014

# Optimization of irrigation scheduling schemes for sugarcane



Testing of SDI



Installation of 63 mm HDPE mainline for furrow irrigation



# Optimization of irrigation scheduling schemes for sugarcane



2-Hp Jet pump for SDI system



7-Hp Diesel engine powered centrifugal pump for furrow irrigation

# Optimization of irrigation scheduling schemes for sugarcane



Pumphouse with concrete reservoirs

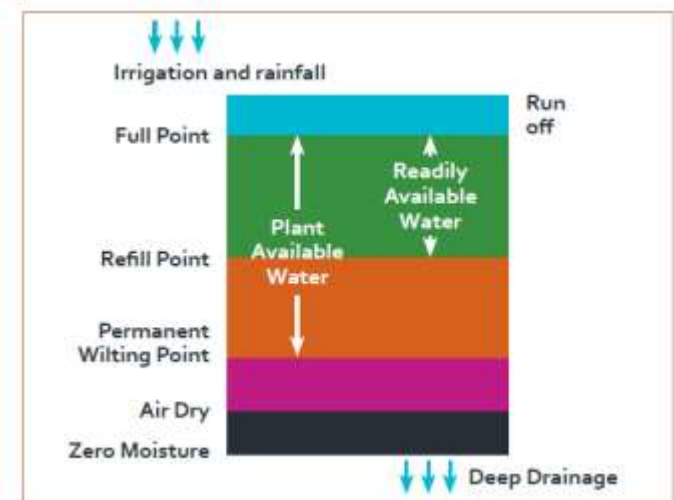
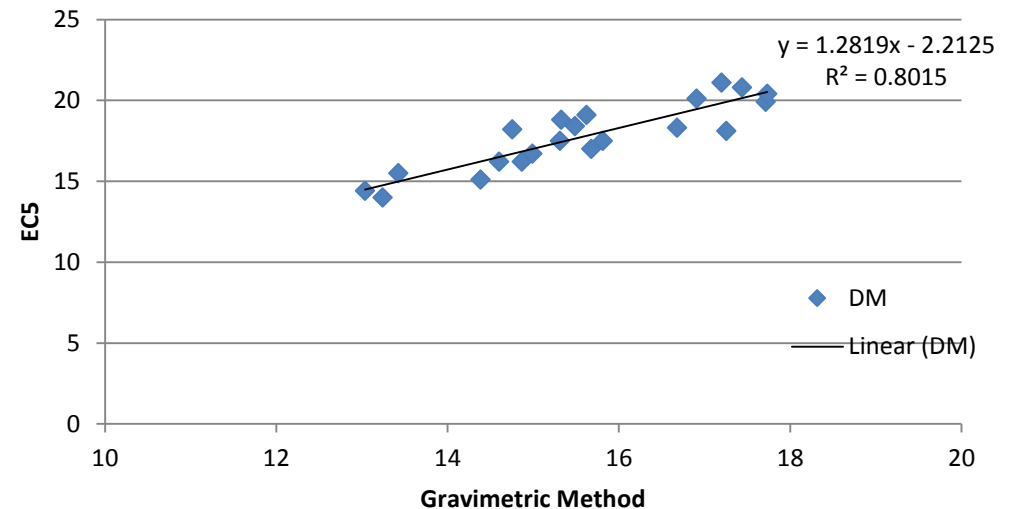


Separate mainlines for drip and furrow irrigation system

# Optimization of irrigation scheduling schemes for sugarcane



Calibration of Decagon EC-5 soil moisture sensors







**Installation of EC-5 soil moisture sensors and data loggers**



# Optimization of irrigation scheduling schemes for sugarcane



Preparation of planting material



Planting of seed pieces

The experimental area was manually planted to sugarcane on December 18, 2014 at a rate of 30,000 (3 lacs) seed pieces per hectare. The sugarcane variety used for the experiment was PHIL 2000-2569.

# Optimization of irrigation scheduling schemes for sugarcane

## Soil analysis

Sample	Texture	pH	OM%	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)
298	Loamy sand	6.25	0.8	59	106	652	69
299	Loamy sand	6.10	0.3	62	131	682	81
300	Loamy Sand	6.28	0.5	100	95	695	70
301	Loamy sand	6.14	0.6	74	121	663	65

Field Capacity – 26.36%    Permanent Wilting Point – 7%    Bulk density – 1.24



# Optimization of irrigation scheduling schemes for sugarcane



Preparation of fertilizer material

## Fertilizer Rates

### Basal Application:

Urea (46-0-0) = 4.25 bags/ha or 1,988.96gms/plot

Potash (0-0-60) = 2.375 bags/ha or 1,111.48gms/plot

### 2<sup>nd</sup> Dosage:

Urea (46-0-0) = 4 bags/ha or 1,871.96 gms/plot

Potash (0-0-60 ) = 2.25 bags/ha or 1,052.98 gms/plot



Application of basal fertilizer

# Optimization of irrigation scheduling schemes for sugarcane



HOBO Automatic Weather Station installed at LAREC (Jan 9, 2015)

# Optimization of irrigation scheduling schemes for sugarcane



**Monitoring Soil moisture content**





Drip Irrigated Plots  
February 13, 2015



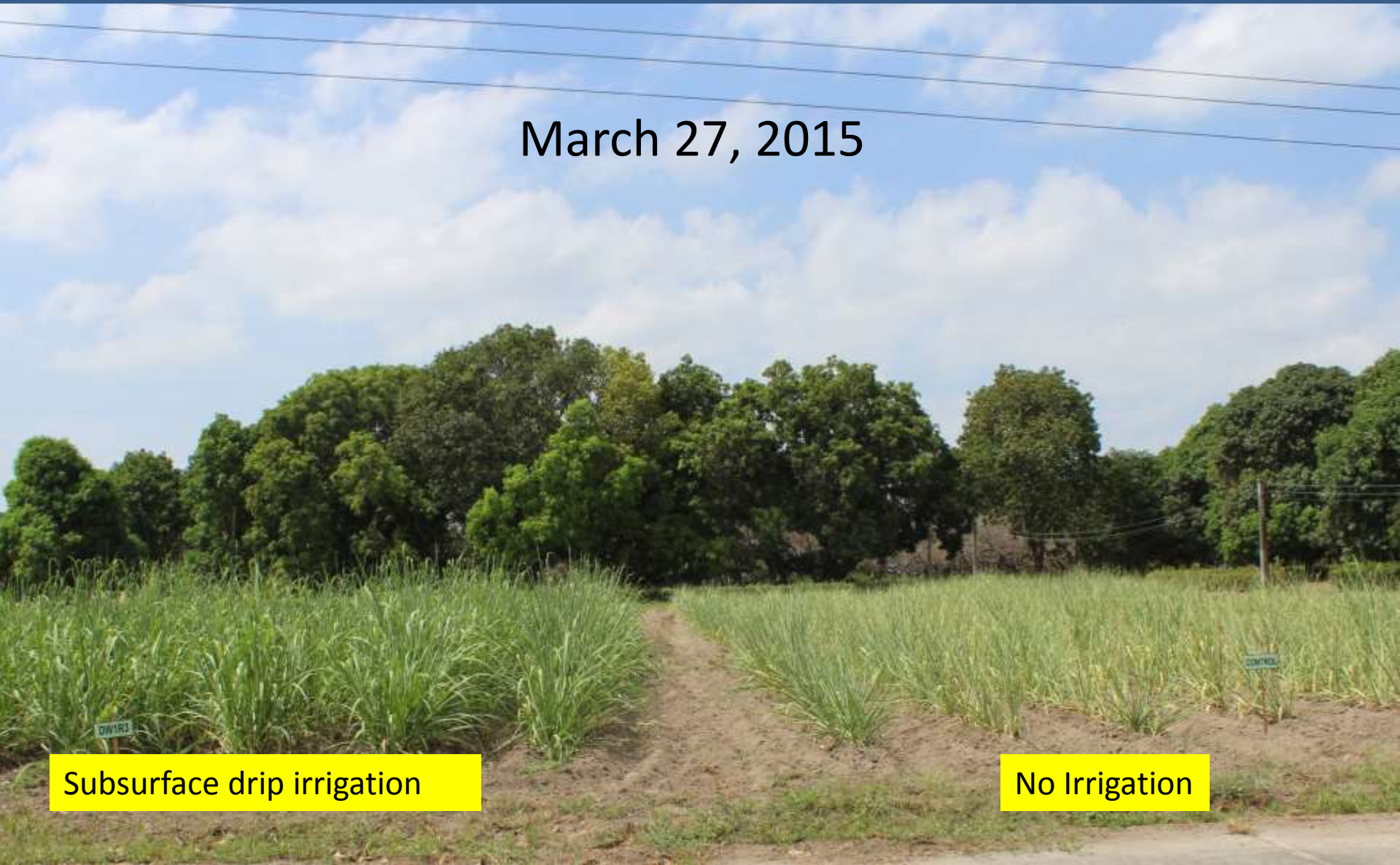


Furrow Irrigated Plots  
February 13, 2015



# Optimization of irrigation scheduling schemes for sugarcane

March 27, 2015



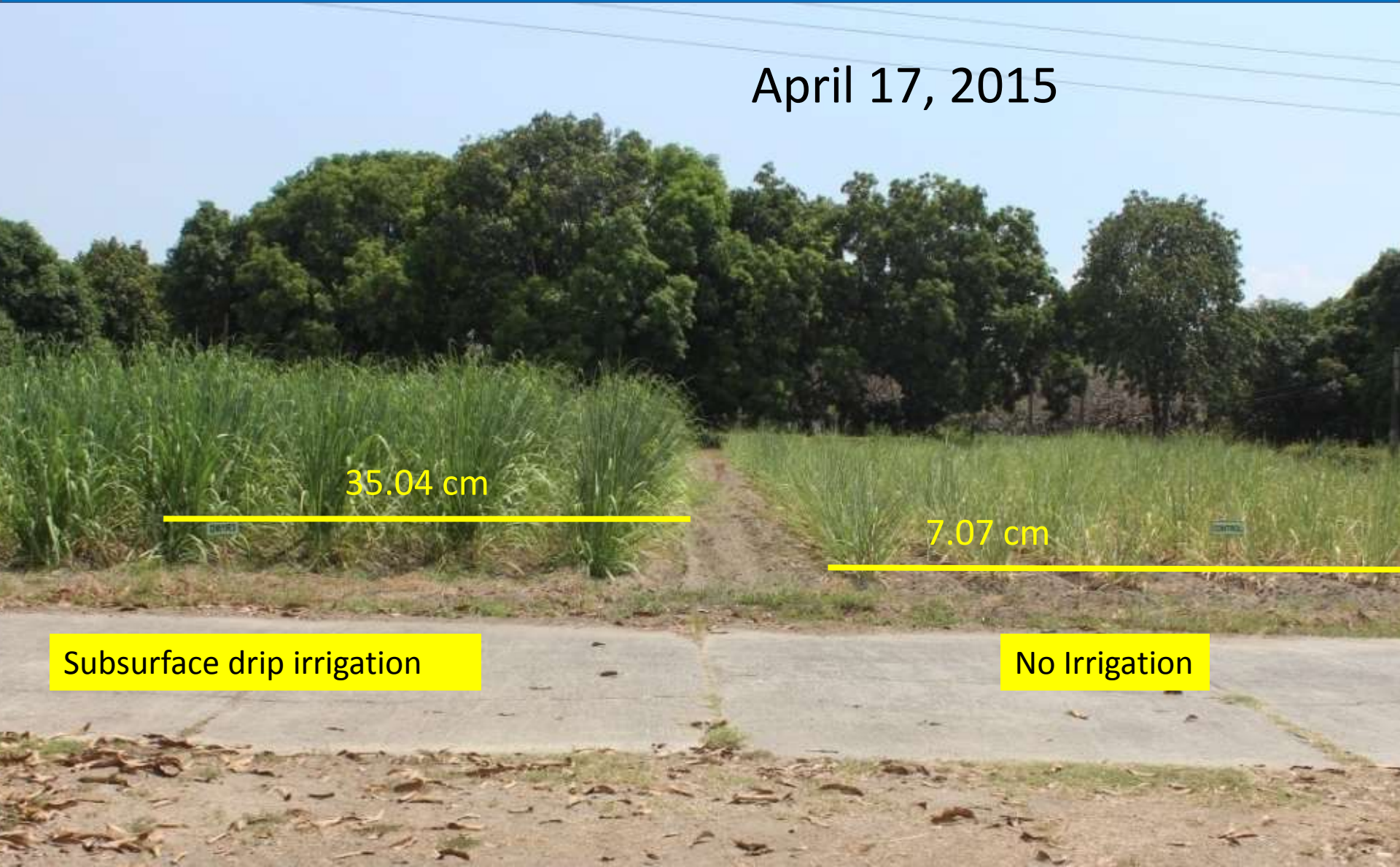
Subsurface drip irrigation

No Irrigation



# Optimization of irrigation scheduling schemes for sugarcane

April 17, 2015



35.04 cm

7.07 cm

Subsurface drip irrigation

No Irrigation



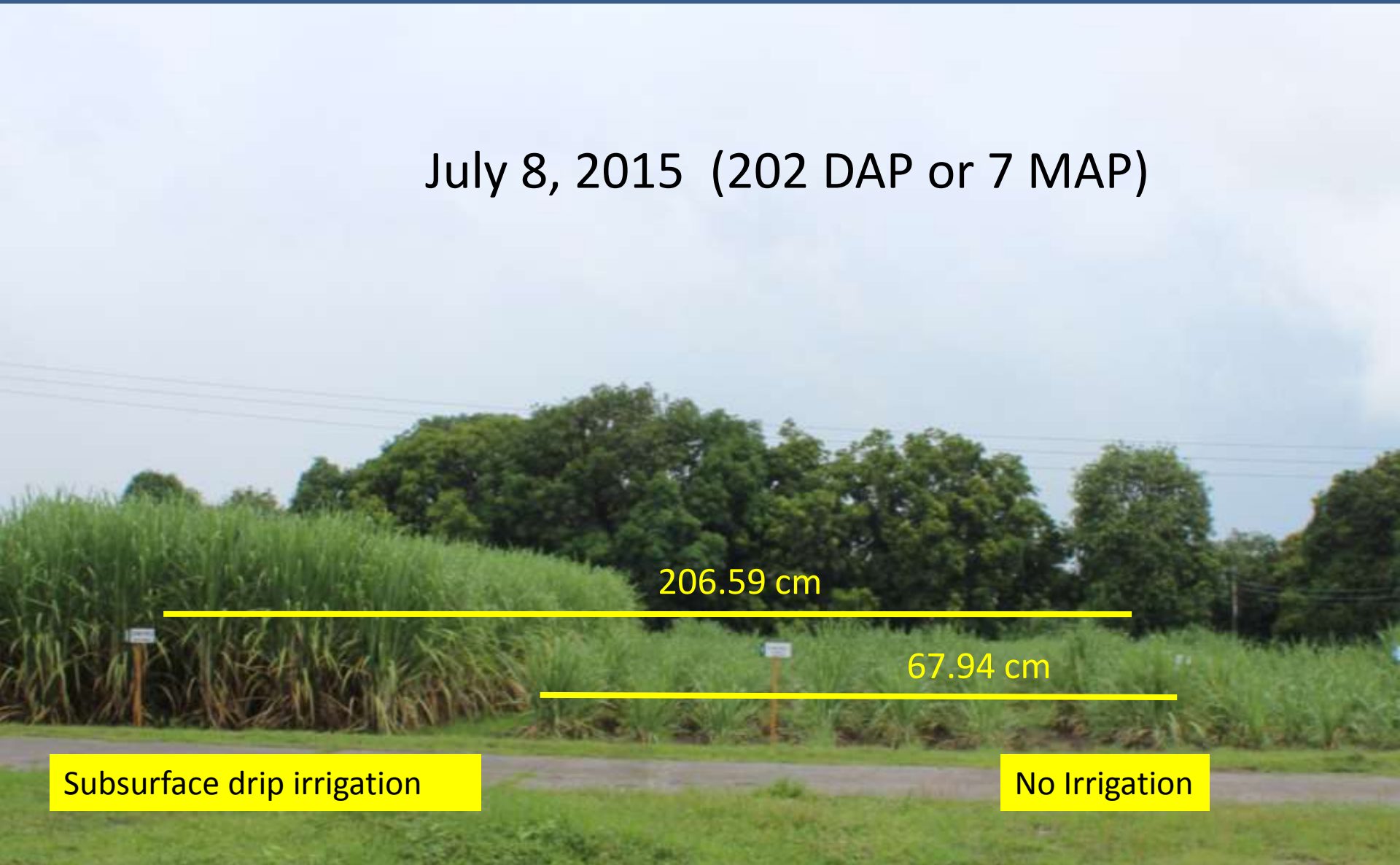
# Optimization of irrigation scheduling schemes for sugarcane

June 4, 2015 (168 DAP)



# Optimization of irrigation scheduling schemes for sugarcane

July 8, 2015 (202 DAP or 7 MAP)



206.59 cm

67.94 cm

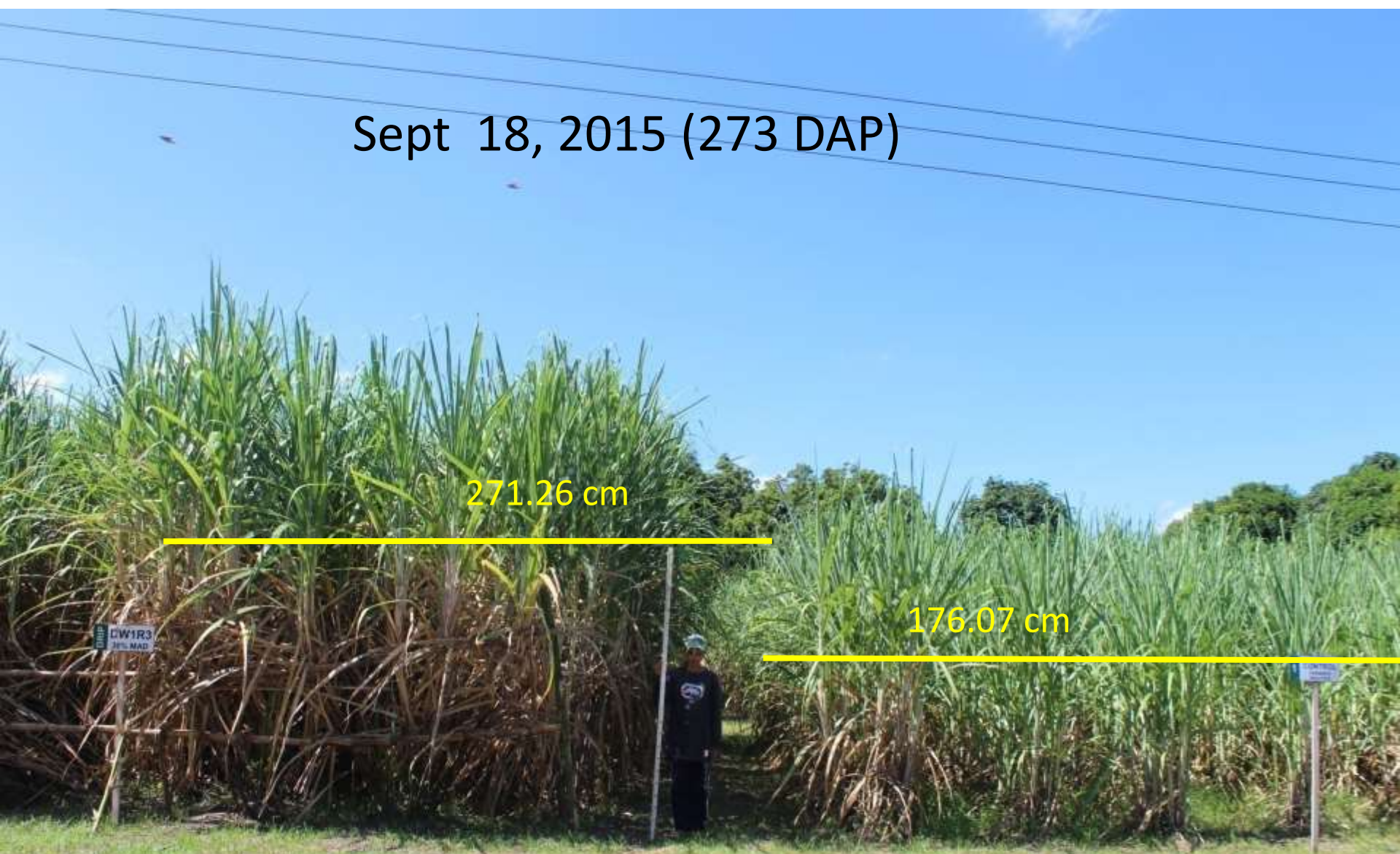
Subsurface drip irrigation

No Irrigation



# Optimization of irrigation scheduling schemes for sugarcane

Sept 18, 2015 (273 DAP)





# Optimization of irrigation scheduling schemes for sugarcane



**Stalk Height Measurement**



# Optimization of irrigation scheduling schemes for sugarcane



**Stalk Diameter Measurement**





















# Optimization of irrigation scheduling schemes for sugarcane

## Germination Data

Treatments	R1	R2	R3	Avg	Treatment Average
FW1	98.26	98.96	99.31	98.84	99.00
FW2	98.96	99.31	98.96	99.08	
FW3	98.61	99.31	99.31	99.08	
DW1	99.31	98.61	98.61	98.84	99.04
DW2	98.96	98.96	99.31	99.08	
DW3	98.96	99.65	98.96	99.19	
Control	97.92	94.79	92.71	95.14	95.14

# Optimization of irrigation scheduling schemes for sugarcane

Crop Height, m December2015

TREATMENT	R1	R2	R3	MEAN
FW1	4.13	4.02	3.75	3.97
FW2	3.75	4.10	3.80	3.88
FW3	3.82	3.73	4.22	3.92
DW2	3.80	3.49	3.46	3.58
DW1	3.43	3.37	3.71	3.50
DW3	3.39	3.28	3.24	3.30
Control	2.26	2.12	2.37	2.25



# Optimization of irrigation scheduling schemes for sugarcane

Crop Height ,December 2015 (m)

## Comparison Among Means

NAME ID	MEAN	RANKED AT PROBABILITY LEVEL 0.5
FW1	3.9667	A
FW3	3.9233	AB
FW2	3.8833	AB
DW2	3.5833	BC
DW1	3.5033	C
DW3	3.3033	C
Control	2.25	D

# Optimization of irrigation scheduling schemes for sugarcane

Millable stalk length, December 2015 (m)

TREATMENT	R1	R2	R3	MEAN
FW1	3.49	3.31	3.11	3.30
FW3	3.28	3.1	3.47	3.28
FW2	3.12	3.45	3.14	3.24
DW2	3.22	2.82	2.77	2.94
DW1	2.65	2.66	3.15	2.82
DW3	2.65	2.68	2.6	2.64
Control	1.7	1.55	1.73	1.66



# Optimization of irrigation scheduling schemes for sugarcane

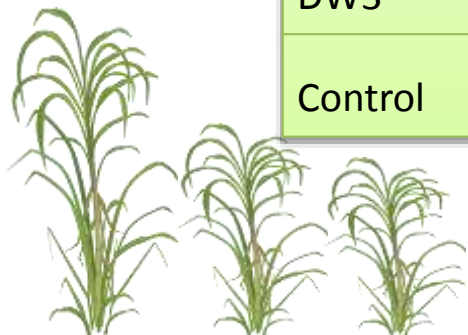
Millable stalk length, December 2015 (m)

FW1	3.3033	A
FW3	3.2833	A
FW2	3.2367	A
DW2	2.9367	AB
DW1	2.8200	B
DW3	2.6433	B
Control	1.6600	C

# Optimization of irrigation scheduling schemes for sugarcane

Total weight of four (4) inner rows at harvest (kgs)

TREATMENT	R1	R2	R3	MEAN
FW1	1143	1369	1108	1,206.67
FW2	1217	1314	1199	1,243.33
FW3	1255	1170	1124	1,183.00
DW1	994	1042	1121	1,052.33
DW2	1014	1161	1065	1,080.00
DW3	1040	893	790	907.67
Control	482	442	488	470.67





# Optimization of irrigation scheduling schemes for sugarcane

Weight per plot in kgs, December 2015

Comparison among means

NAME ID	MEAN	RANKED AT PROBABILITY LEVEL 0.5
FW2	1243.3333	A
FW1	1206.6667	AB
FW3	1183.0000	AB
DW2	1080.0000	AB
DW1	1052.3333	BC
DW3	907.6667	C
Control	470.6667	D

# Optimization of irrigation scheduling schemes for sugarcane

## Yield in Tc/ha and Estimated Bags of sugar per hectare

Treatment	Replication			Avg kg/plot	Tc/ha	Lkg/Tc	Estimated Bags of Sugar/ha
	R1	R2	R3				
FW1	1,143	1,369	1,108	1,206.67	193.38	1.64	316.49
FW2	1,217	1,314	1,199	1,243.33	199.25	1.87	372.60
FW3	1,255	1,170	1,124	1,183.00	189.58	1.72	325.45
Avg Furrow				1,211.00	194.07	1.74	338.18
DW1	994	1,042	1,121	1,052.33	168.64	1.71	288.94
DW2	1,014	1,161	1,065	1,080.00	173.08	1.88	325.96
DW3	1,040	893	790	907.67	145.46	1.88	272.98
Avg Drip				1,013.33	162.39	1.82	295.96
Control	482	442	488	470.67	75.43	1.73	130.24



# Irrigation Amounts

Irrigation Treatment	Volume of water delivered m <sup>3</sup> /ha	Average Volume m <sup>3</sup> /ha
D1	3,033.50	2,595.02
D2	2,608.42	
D3	2,143.16	
F1	7,600.26	6,790.23
F2	7,112.15	
F3	5,658.29	

# Optimization of irrigation scheduling schemes for sugarcane

## Water Savings (%)

The water saving in drip over furrow irrigation system was calculated as under:

$$Ws (\%) = (Wa - Wb)/Wa \times 100$$

Where,

WS = Water saving (in %)

Wa = Total water used in furrow irrigation system (m<sup>3</sup>/ha)

Wb = Total water used in drip irrigation system (m<sup>3</sup>/ha)

Wa = 6,790.23 m<sup>3</sup>/ha

Wb = 2,595.02 m<sup>3</sup>/ha

**WS = 61.78%**



# Optimization of irrigation scheduling schemes for sugarcane

## Water Productivity

Treatments	Water consumed liters/ha	Yield kgs/ha	Water productivity (liters/kg)	Avg Water Productivity (liters/kg)
DW1	3,033,500	168,640	17.99	15.93
DW2	2,608,420	173,080	15.07	
DW3	2,143,160	145,460	14.73	
FW1	7,600,260	193,380	39.30	34.95
FW2	7,112,150	199,250	35.69	
FW3	5,658,290	189,580	29.85	

# Irrigation Practices in the Sugarcane Industry : Australian Experience



# Australian Sugar Industry

- Australia's sugar industry accounts for 2.7% of world sugar production but is the world's 3rd largest exporter of sugar.
- There are about 4,000 cane farming businesses supplying 24 mills owned by 8 milling companies.
- Approximately 30% of sugarcane businesses are greater than 125 hectares and account for about 70% of total production.
- Sugar Research Australia (SRA) is the primary RD&E provider for the Australian sugarcane industry, working in partnership with over 30 public and private research organisations.
- The value of Australia's sugar exports was \$1.8 billion in 2015/16.
- The 2015 season yielded 4.8 million tonnes of sugar from 34.8 million tonnes of cane, across 381,000 hectares



# Sugar Research Australia

The core responsibilities of SRA are to:

- Deliver cost-effective research and development services to the Australian sugar industry to enhance its viability, competitiveness and sustainability;
- Carry-out, coordinate and provide funding for R&D activities in relation to the Australian sugar industry;
- Facilitate the dissemination, extension, adoption and commercialisation of results of R&D activities; and
- Support and develop industry research capacity.



# Sugarcane Producing Areas in Australia



# **PRECISION AGRICULTURE**

Precision agriculture (PA) is a farm management technique that addresses the variability of the land and resulting variability in yield to improve farm productivity and profitability.

PA can also help address variability in weed, pest and disease occurrence and moisture supply.



# **Adoption of PA in the Australian Sugar Industry**

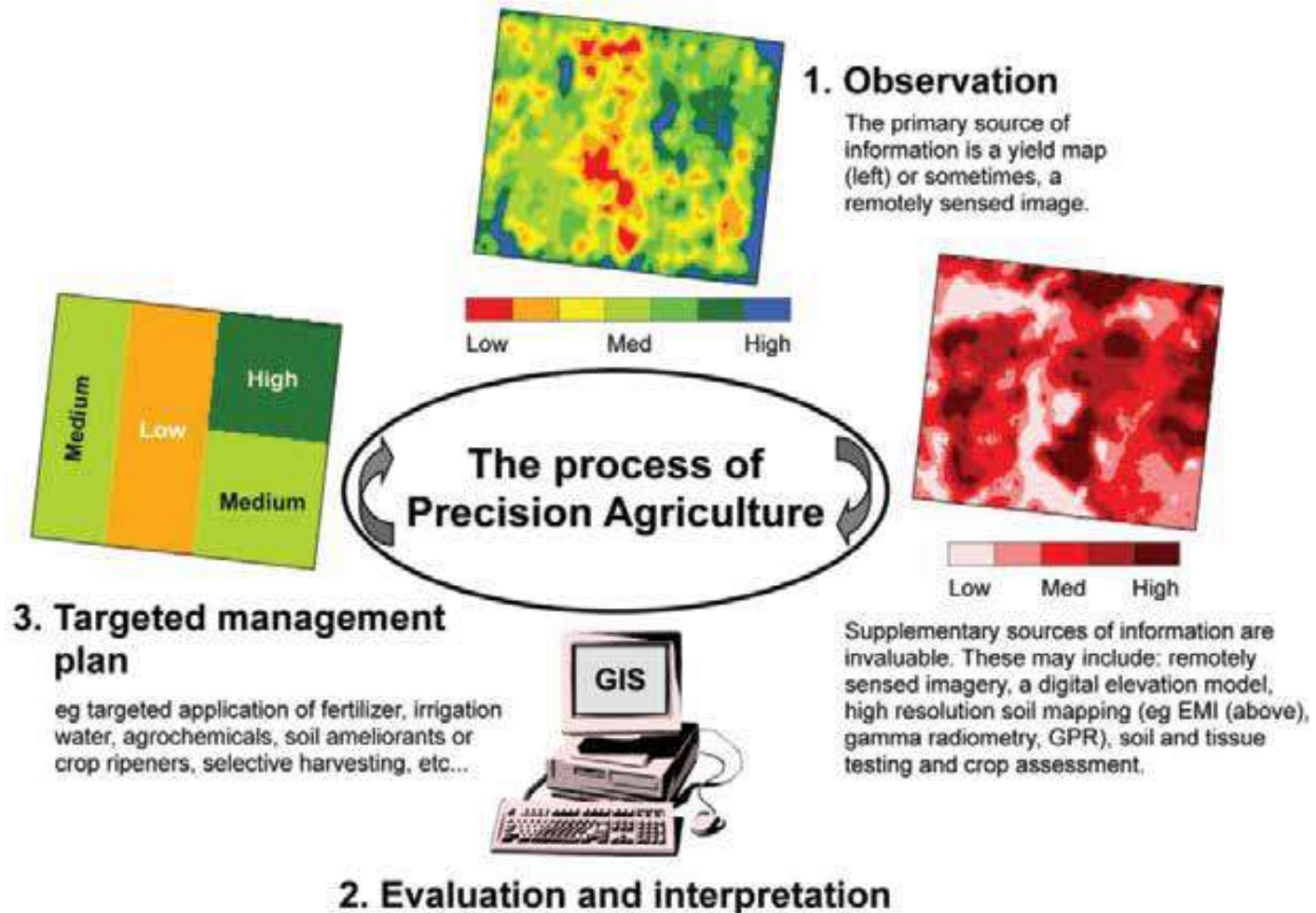
As production costs increase, along with concern about the environmental impacts of agriculture, there is a need for increased efficiency on the farm and for growers to demonstrate that they are using the best available tools and practices. Also, growers need to continually develop their ability to increase profitability of farming enterprise and be competitive in the modern marketplace.

# Implementing PA Precision Agriculture for the Sugarcane Industry

PA as defined is identifying and managing variability on the farm and in productivity. In cropping industries, this is also termed “**Site-specific crop management (SSCM)**”.

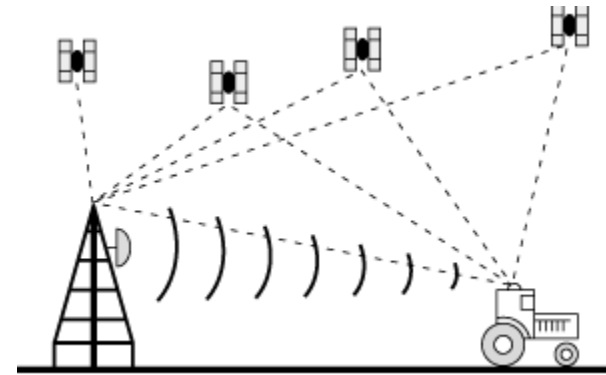
PA or SSCM can be considered as the application of information technologies, together with production experience, to:

- optimize production efficiency
- optimize crop quality
- minimize environmental impacts
- minimize risk to the grower



Cyclical process of Precision Agriculture





Differential GPS receiver used for satellite navigation. The top image shows the GPS receiver and the antennae that receives the differential signal mounted on top of the tractor. The bottom image shows the tractor operator using the in-cab display for GPS guidance in the field.

# Navigational Uses of GPS

- **Guidance**

GPS guides machinery but the operator controls it. The guidance system uses a signalling device to prompt the driver to maintain a predetermined path. It needs sub-meter accuracy of GPS signal.

- **Auto steer**

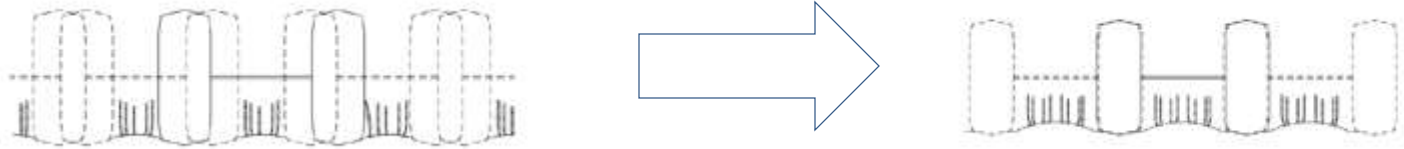
Removes operator from most steering operations. For safety, auto steer systems have an automatic override system as soon as the operator takes control of the steering wheel. These systems also monitor the quality of the satellite signal. It needs centimeter accuracy of GPS signal.

- **Controlled traffic**

The use of guidance or auto steer to confine all machinery loads to permanent traffic lanes.

- **Accurate inter-row cultivation, spraying and planting.**

# Controlled-traffic Farming System



Dual-row, controlled-traffic farming system in which tire tracks are confined to relatively narrow traffic lanes between beds.



## **Economic Benefits of Controlled Traffic**

- tractor power requirements reduced by at least 30 per cent
- faster access to field after rain
- greater infiltration of rainfall, resulting in less run-off
- better soil health, with more plant-available water
- less tillage after harvests

# GIS and Variable Rate Applications

Farmers often know from experience where high- and low yielding areas on their farm are, or where they have particular problems.

The value of using GIS to record and analyse this information is that growers can keep records over time and compare multiple data sets (for example, soils, yield and elevation) at the same time to create management zones.

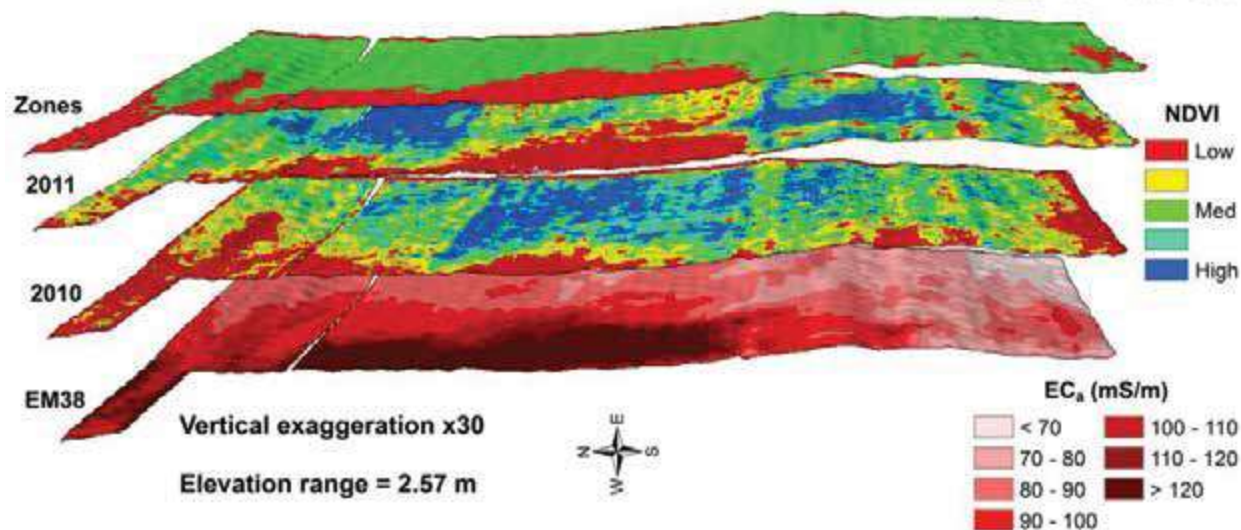
When this information is in digital form, variable-rate prescriptions can be created and directly transferred into a tractor display unit with GPS capability to streamline a site-specific management system.



## CSE022 - Pozzebon field site - Paddock zoning 2010-2011

EM38 soil survey  
Ikonos satellite imagery  
Elevation via RTK GPS

	mS/m	2010	2011
117a	0.58	0.45	
85b	0.62	0.53	





# Agricultural Uses of Remote Sensing

A series of images collected over time can show changes in plant growth, soils, erosion or other physical processes. Some agricultural uses of remote sensing include:

- estimating crop yields
- detecting diseases
- identifying pest and weed coverage
- evaluating uniformity of irrigation
- observing changes in plant growth over time
- assessing the impact of severe weather
- determining the location and extent of crop stress.

Since sugarcane is a crop that cannot be easily observed once it reaches a certain height, RS can be a useful management tool that doesn't require physical access to the crop. Problems within a field may be identified remotely before they can be identified on the ground.

# Uses of RS in Sugarcane

Remote sensing has been used for many different purposes in sugarcane growing and harvesting. Some potential uses of imagery may include:

- forecasting regional yield
- producing farm-level and block-level yield maps
- evaluating the effectiveness of irrigation
- screening research and breeding trials
- identifying and managing diseases



**Furrow Irrigation for  
Sugarcane using lay flat hose**











## Automated Furrow Irrigation for Sugarcane





# Automated Furrow Irrigation for Sugarcane

Accurate data is collected through probes and sensors, and accessed in real time through a software for real time monitoring and analysis. With ever increasing demand on Australia's limited water resources and the desire to increase productivity, research has continued to develop Automation Control Systems to improve the operation and efficiency of irrigation systems. The automated irrigation system communicates wirelessly, and the control systems can be logged into remotely using either mobile telemetry or internet connections, so there is no need to be on site to make decisions.







# WiSA Automated Irrigation System







**Irrigation in operation**



# Sensor for runoff water





**Runoff water are collected in ponds for**







**Use of extended tubes at the outlets to reduce erosion**



**Travelling gun sprinkler**











# Center-pivot system with adaptive control for variable rate irrigation













# Solar powered pumping system for drip irrigation





**Head Control  
Unit**





**Submersible  
Pump**







## **Drip-irrigated Sugarcane**













National Center for Engineering in Agriculture

# NCEA's research thematic areas

- (1) Irrigation and water management;
- (2) Sustainable soils and landscapes;
- (3) Precision agriculture;
- (4) Energy conservation and management; and
- (5) Automation, robotics and machine vision



## NCEA research benefits to farming

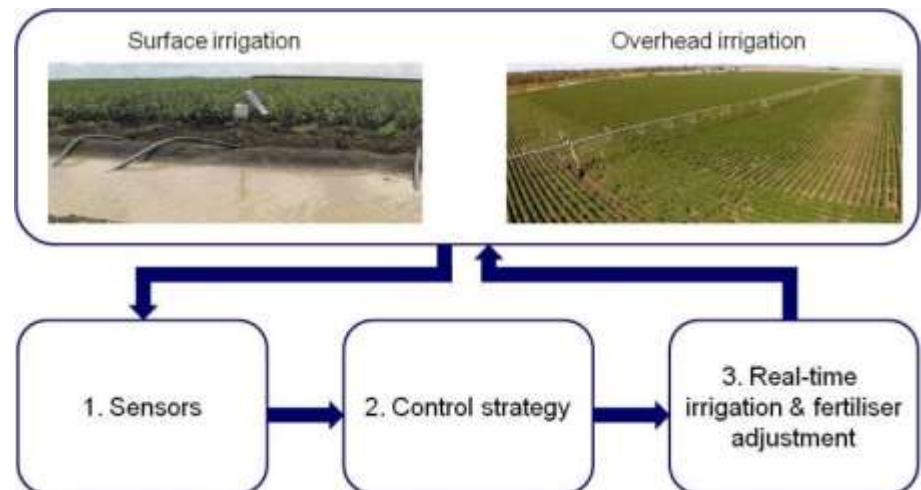
- Automated irrigation systems able to apply water as efficiently as 90%.
- Assessment of controlled traffic farming fine tuning nitrogen management guidelines
- Commercialization of weed sensing technology which can distinguish weeds from crop and apply 80% less herbicide
- Assessment of alternative energy options for the industry





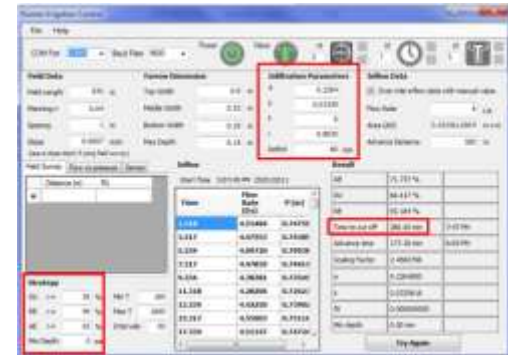
# Irrigation automation research

- Automation enables high resolution data capture and analysis and control
  - Hydraulic optimisation
  - Real-time adaptive irrigation control
  - On-the-go plant and soil sensing technology
- Internet-enabled sensing and control integrated into the irrigation system



# Surface irrigation hydraulic optimization

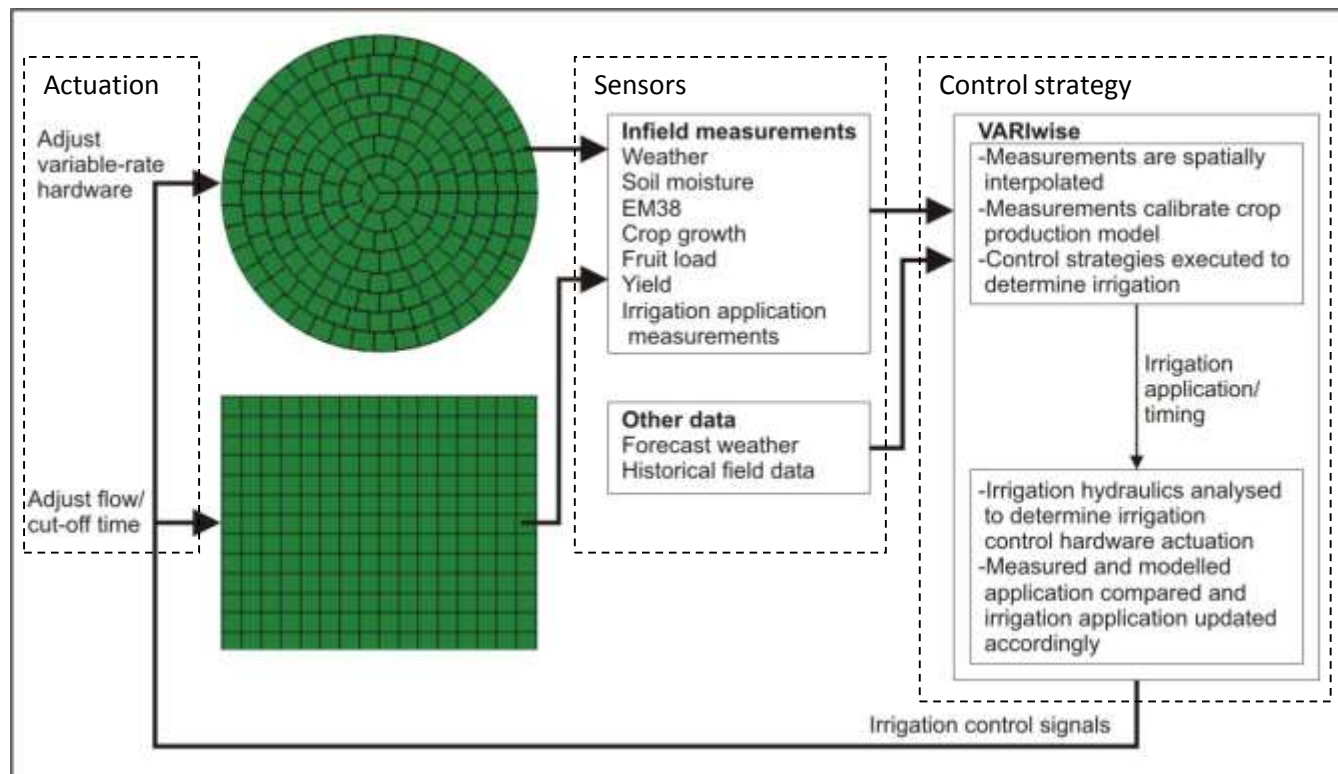
- Real-time optimisation of surface irrigation using 'AutoFurrow'
- Real-time optimisation typically involves:
  1. Inflow measurement
  2. Time for advance front to about midway down the field
  3. Real-time estimation cut-off time that will give maximum performance for that irrigation





# Real-time adaptive irrigation control

- Control methodology developed that can adapt to different irrigation systems and crops



# Adaptive control of surface irrigation

- Accurate hydraulic models are available to determine irrigation application distributions
- Link hydraulic model to a crop production and soil model and control strategy:
  - Crop model estimates crop response to different irrigation applications
  - Control strategy determines irrigation applications
  - Hydraulic model determines spatial distribution of irrigation

As researchers, we have to explore new and improved methodologies, examine, and be open to the adoption of new technologies that have the potential to improve farming operations for food security and increased profitability.





**Thank You!!!**