Water Management: A Complex Balancing Act

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Water and Land Resource Management

- ✓ **Develop and test innovative water conservation and modern irrigation practices to conserve water and reduce agrochemical contamination of soil and water**
- ✓ **Implement irrigation scheduling techniques to enhance water use efficiency**

Field Research Sites

Guyana
- Black Bush Polder
- Parika

St Kitts
- Mansion
- Stapleton

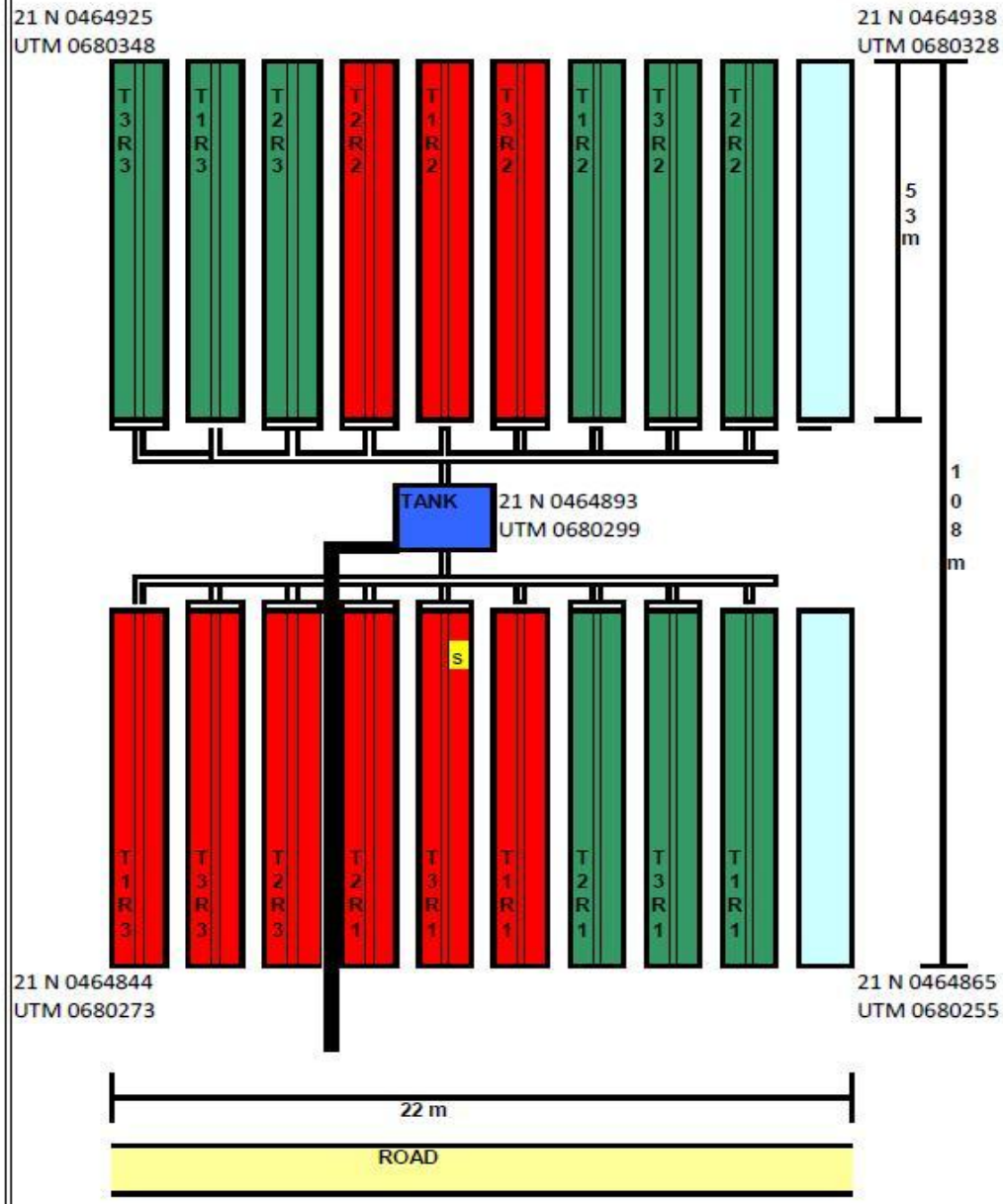
St Lucia
- Black Bay

Soil characteristics of project sites

Project sites	Soil Classification	Particle Size distribution			Field Capacity	Perm Wilting Point	Available Water Content	Trigger value
		Sand	Silt	Clay				
		%	%	%	%	%	%	60% of AWC
St. Kitts	Sandy loam (Monkey Hill Loam)*	71.6	24.2	4.2	23.2	9	14.2	8.5
Black Bush Polder (GUY)	Clay (Corentyne Clay)**	2.3	33.8	63.9	50.1	33.9	16.1	9.7
Parika (GUY)	Silty clay (Mara Series) **	1.0	53.4	45.6	54.5	40.4	14.0	8.5

Source: * 1966, Soil and Land-Use Surveys No. 16 St. Kitts and Nevis
** NAREI

BLACK BUSH POLDER'S PILOT SITE
Farm site: Lallbuchen Owner: Mr. Lesbeholden



S	soil moisture sensor

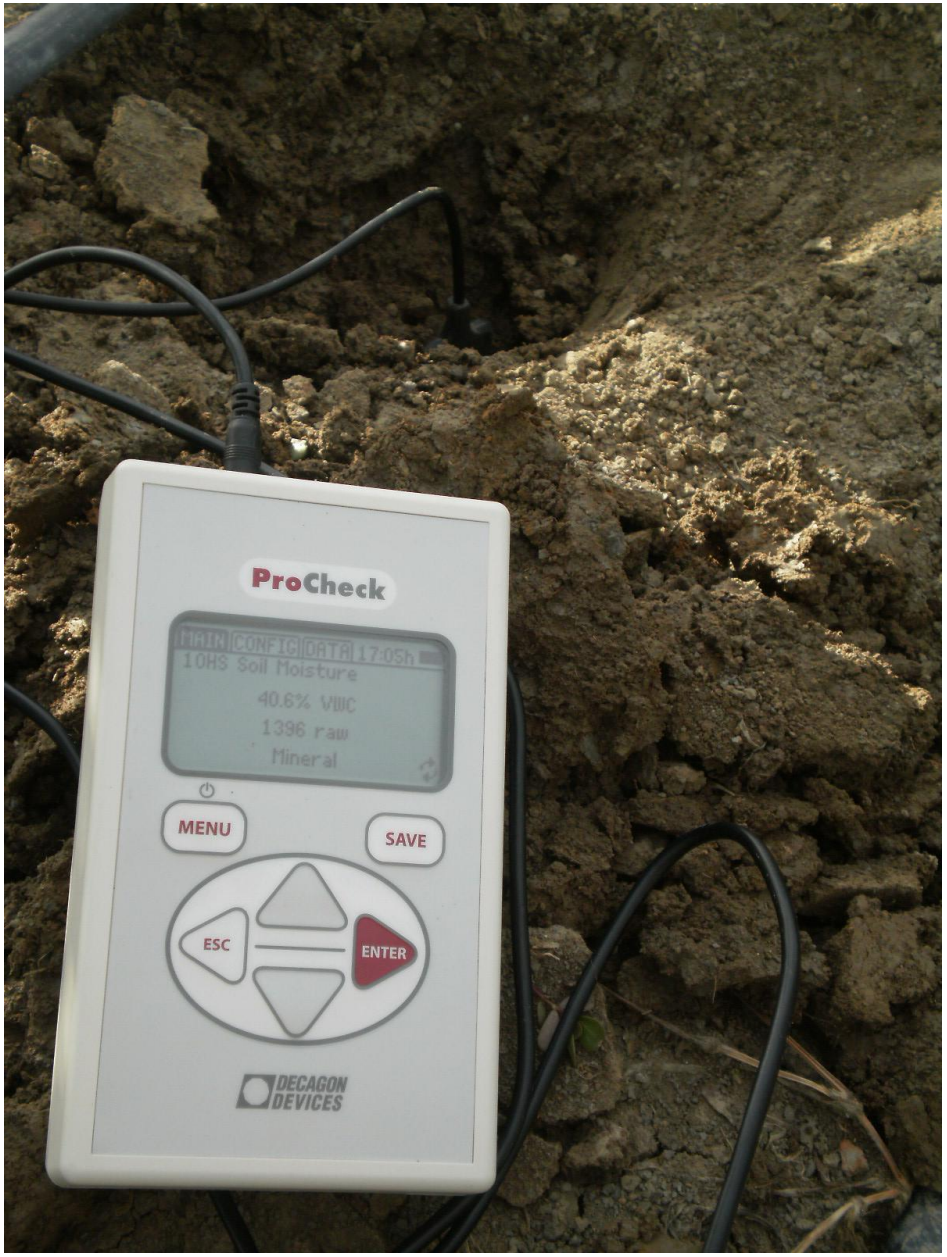
Bora
Tomato
No practice

Dimensions of the drip systems:

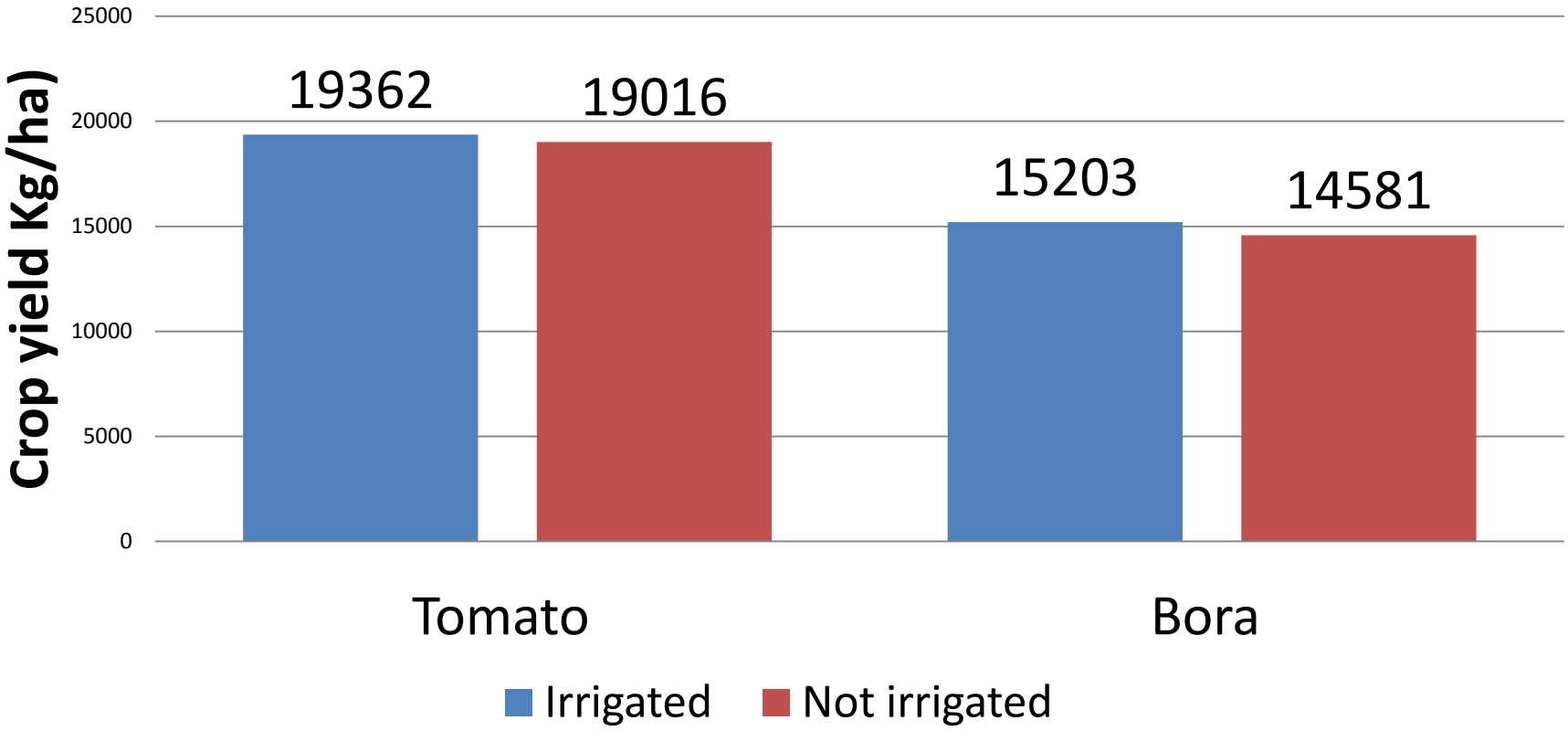
main line = 1"of diameter (or 2.54 cm)
secondary line = 1"of diameter (or 2.54 cm)
drip-line = 5/8" of diameter (or 1.59 cm
Tank = 450 gallons (or 1703.43L)
height = approximadely 2 meters
Flow of the drip irrigation: 500 mL/hour

Area: 2332 m2 or 0.23 ha

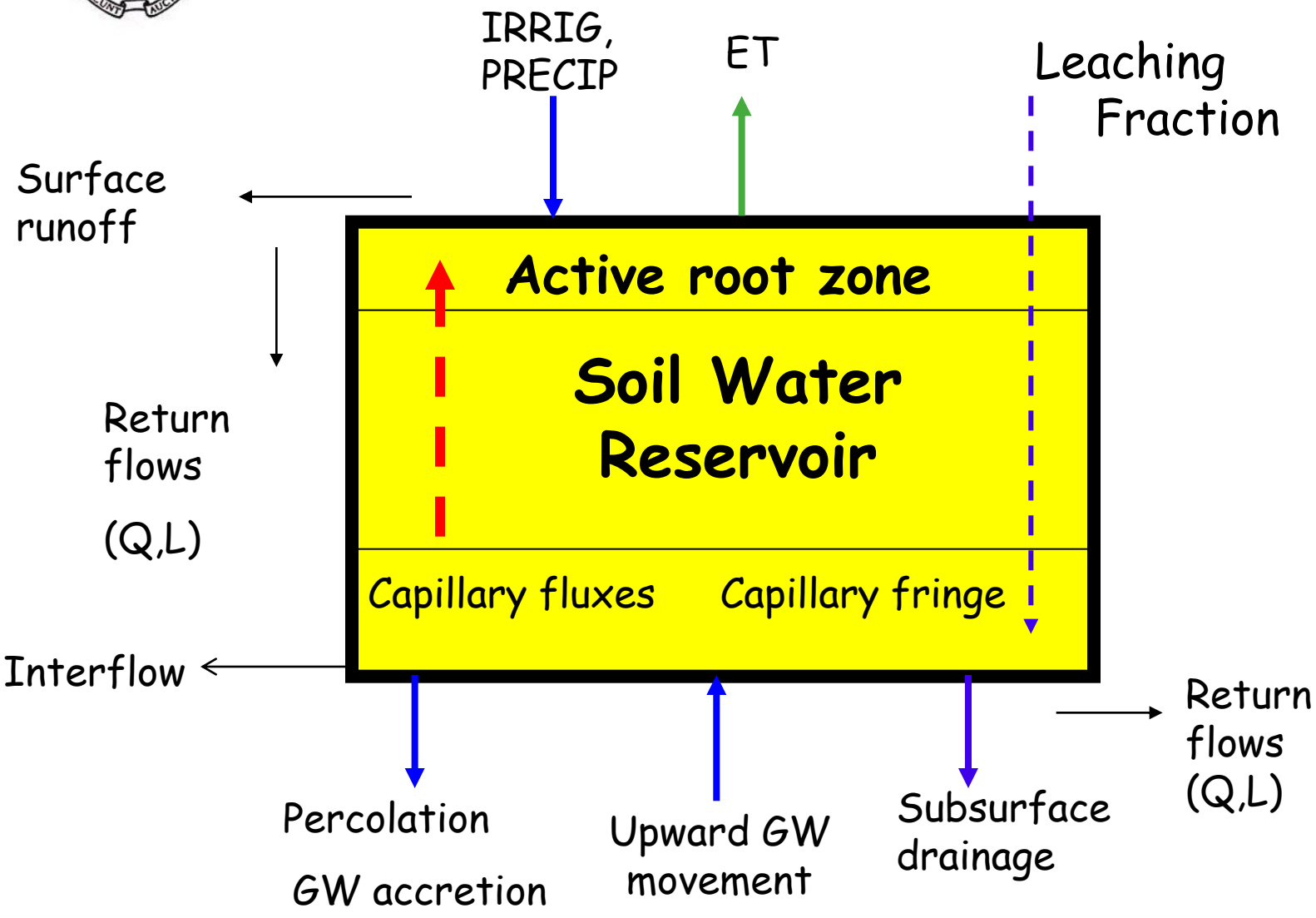
Treatments:
T1R2 = Farmer management, 2nd repetition
T2R2 = 75% of FC, 2nd repetition
T1R1 = Farmer management, 1st repetition
T2R1 = 75% of FC, 1st repetition
T1R3 = Farmer management, 3rd repetition
T2R3 = 75% of FC, 3rd repetition
T3R2 = 100% of FC, 2nd repetition
T3R1 = 100% of FC, 1st repetition


ProCheck
MAIN CONFIG DATA 17:05h
10HS Soil Moisture
40.6% VWC
1396 raw
Mineral
MENU
SAVE
ESC
ENTER
DECAGON DEVICES

Parika – Crop Yields (Kg/ha)



Madramootoo Lab
Soil Water Plant Dynamics Model



Soil Water Balance Model – McGill-IRRIMOD©

$$SWi = SW\,(i-1) - Etci + DP) + (Ii + Reffi)$$

Sw_i = Soil water balance in mm

$SW_{(i-1)}$ = Soil water balance content in the root zone at the end of the previous day, $i-1$ (mm)

ETc_i = Actual Crop Evapotranspiration on day i (mm)

DP= Deep percolation in mm

I_i = Irrigation applied depth on day i (mm)

$Reff_i$ is the Effective rainfall of the day in mm

The FAO-56 Penman-Monteith Equation

$$ET_o = \frac{0.408\,\Delta\,(R_n - G) + \gamma \frac{900}{T+273} u_2\,(e_s - e_a)}{\Delta + \gamma(1 + 0.34\,u_2)}$$

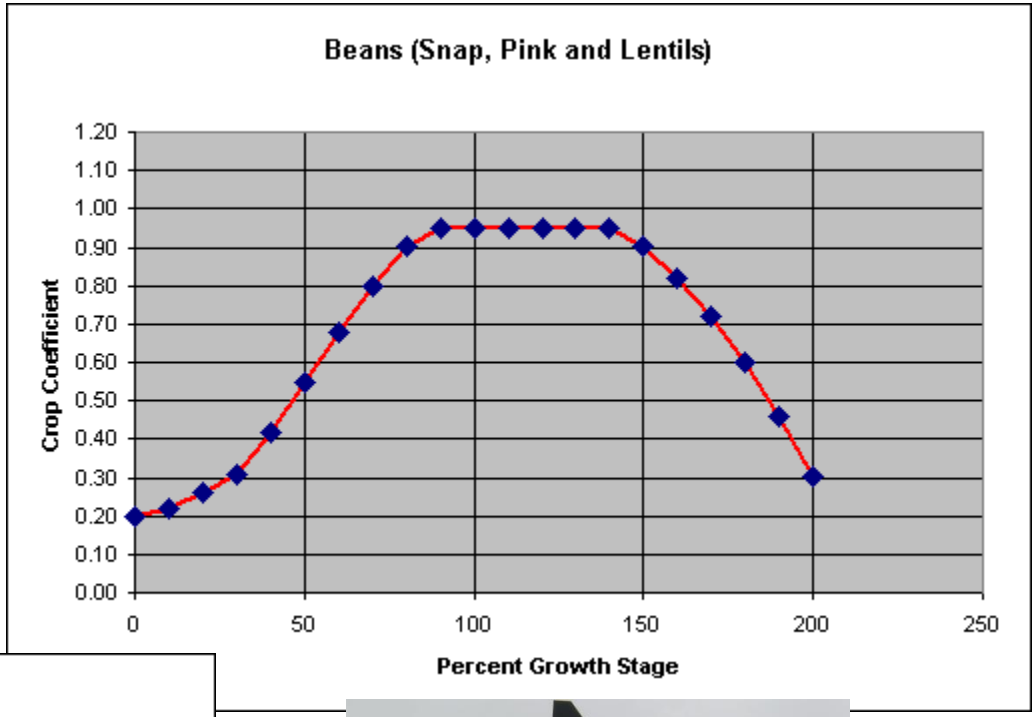
ET_o	grass reference evapotranspiration [mm day^{-1}],
R_n	net radiation at the crop surface [MJ m^{-2} day^{-1}],
G	soil heat flux density [MJ m^{-2} day^{-1}],
T	mean daily air temperature at 2 m height [℃],
u_2	wind speed at 2 m height [m s^{-1}],
e_s	saturation vapor pressure [kPa],
e_a	actual vapor pressure [kPa],
e_s-e_a	saturation vapor pressure deficit [kPa],
Δ	slope vapor pressure curve [kPa ℃ $^{-1}$],
γ	psychrometric constant [kPa ℃ $^{-1}$].

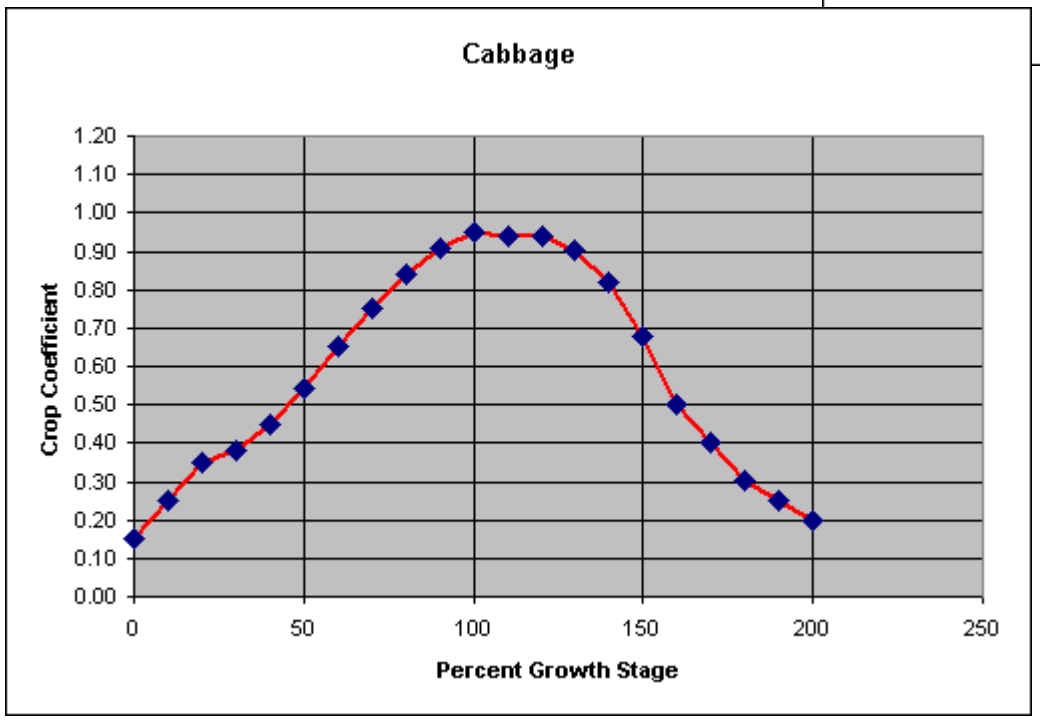
Crop Evapotranspiration (ET_c)

$$ETc = Kc * ETo$$

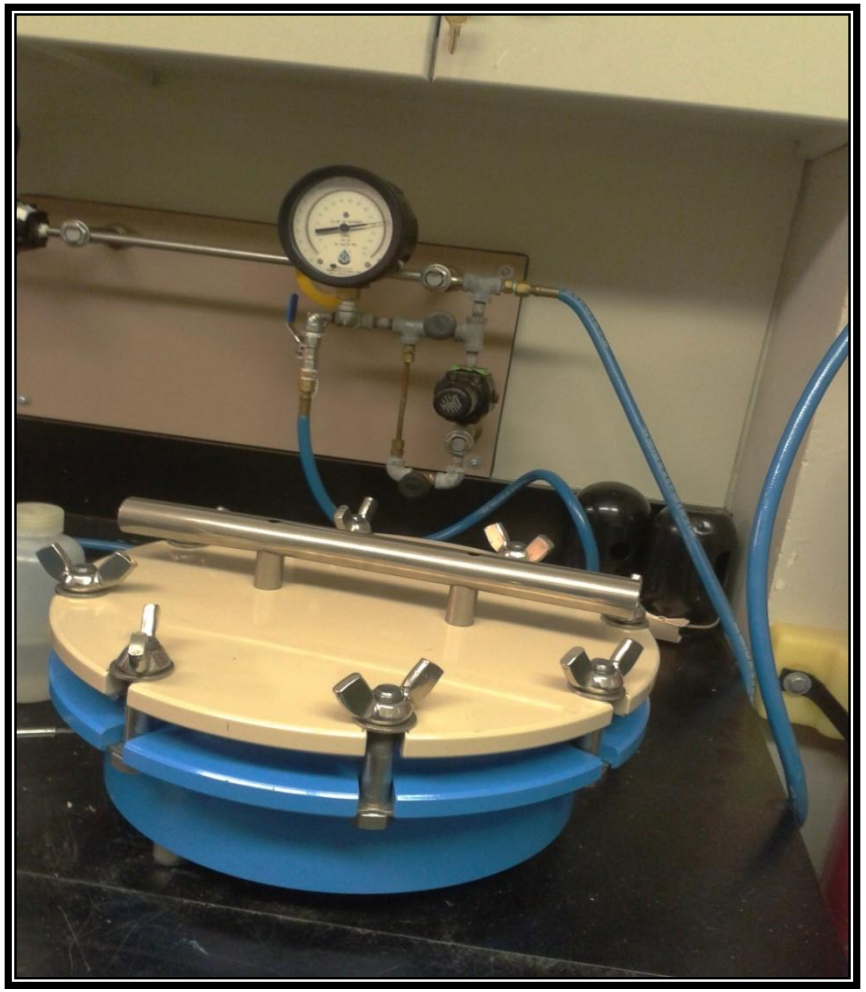
ETo= reference evapotranspiration
Kc = crop coefficient

ETcrop = ETo * Kc





Determination of the Soil Water Retention Curve



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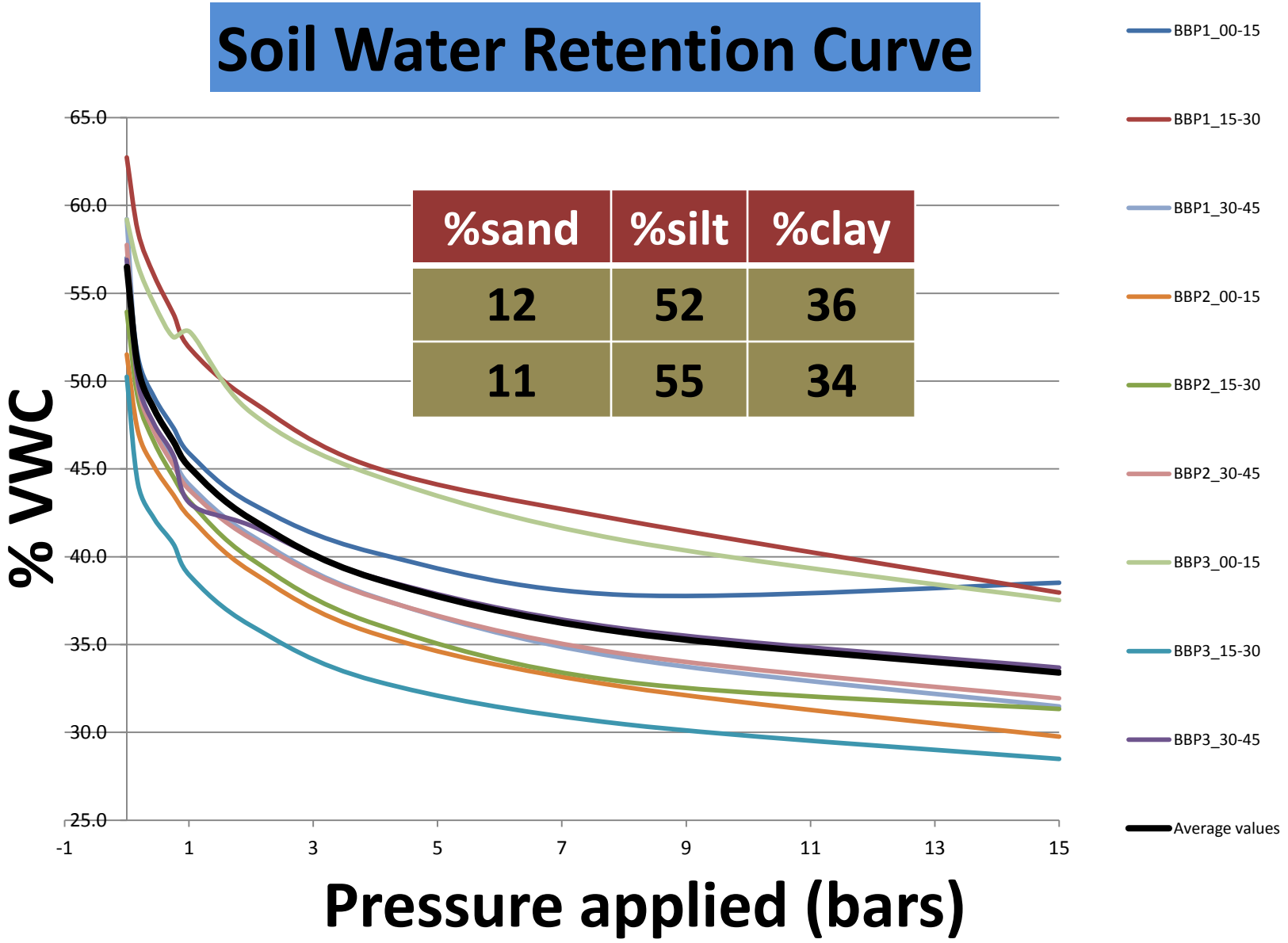
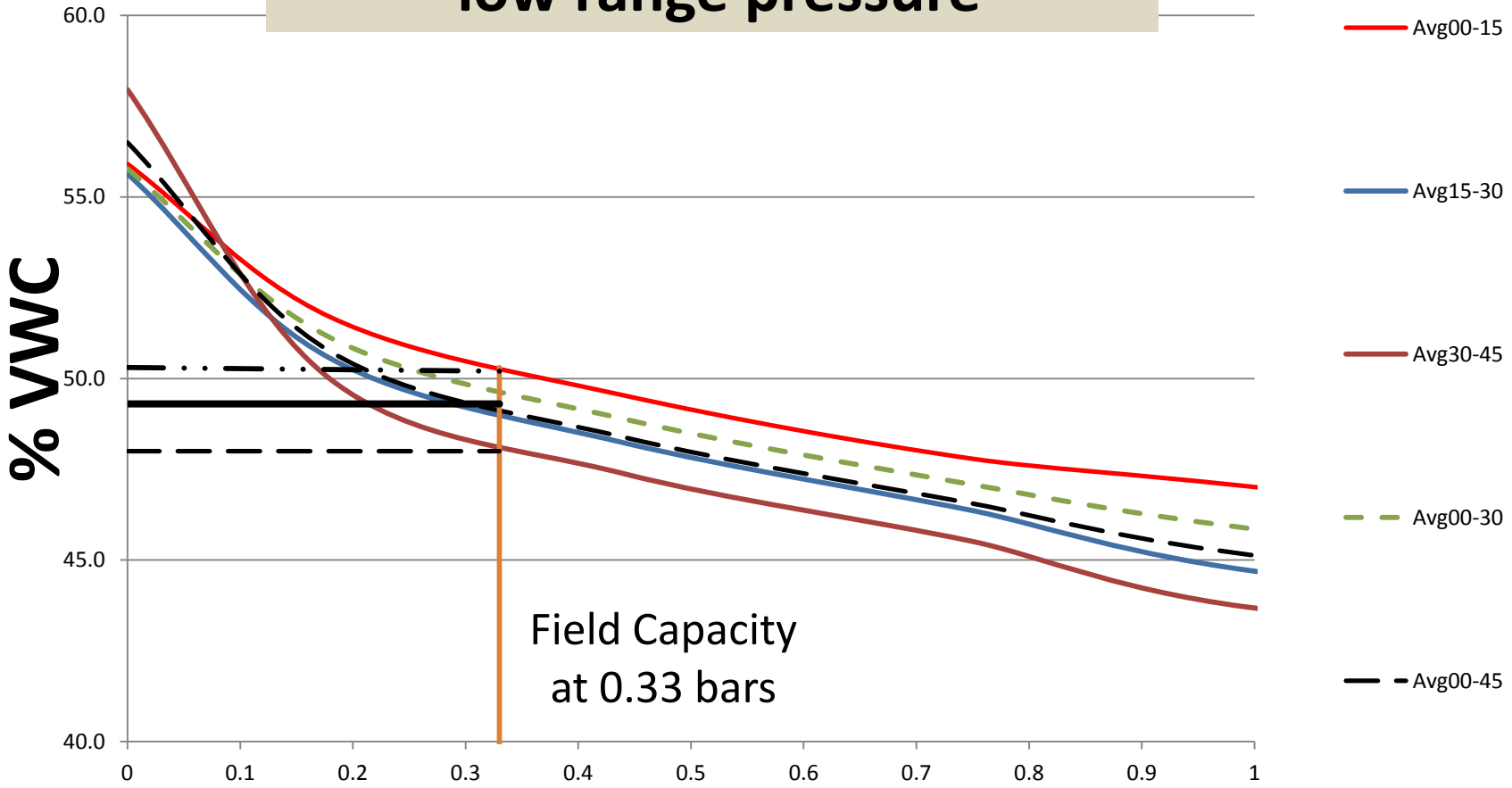
Pressure plate apparatus

Soil Water Plant Dynamics Lab

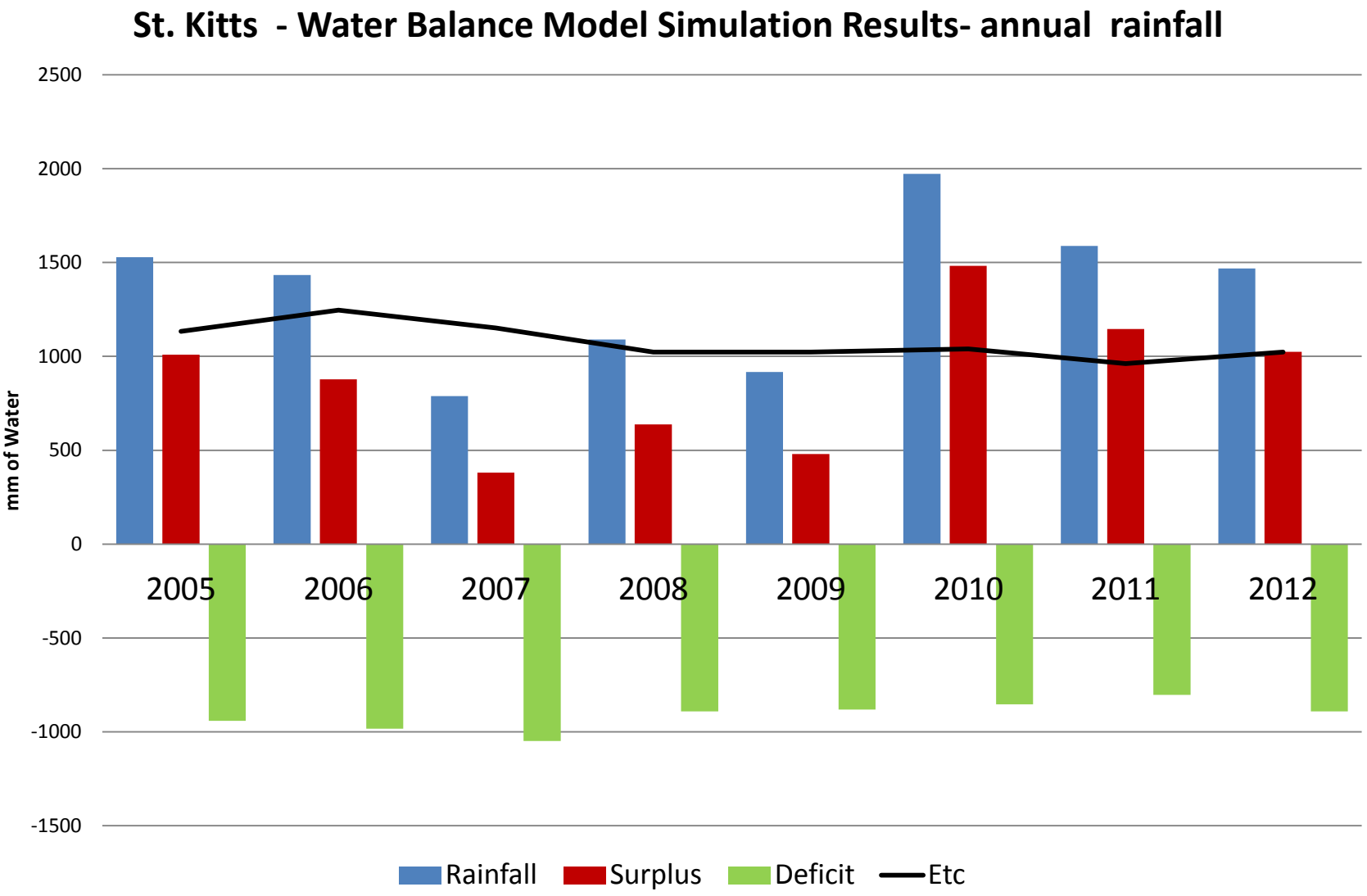
Soil Water Retention Curve



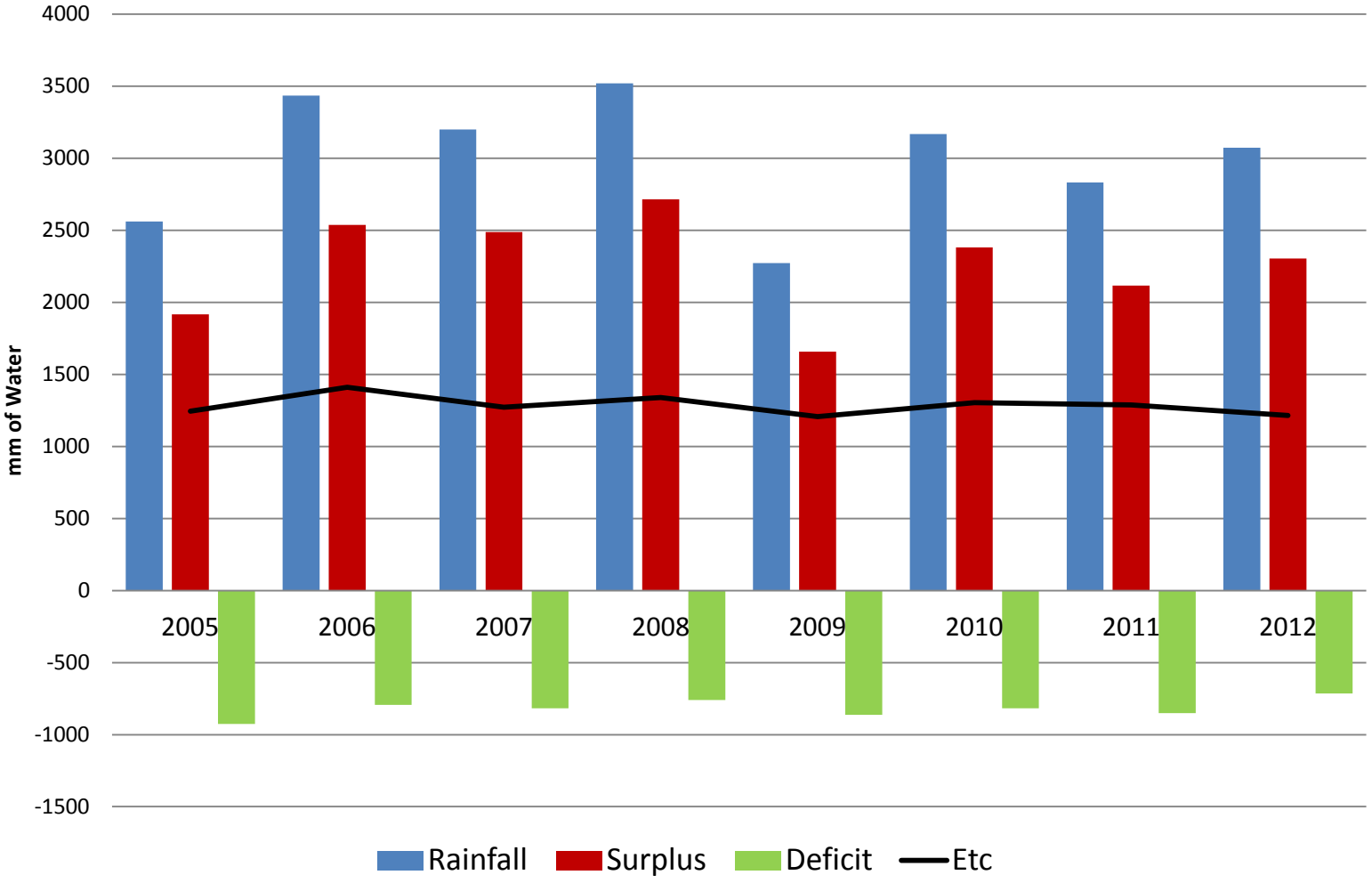
Soil Water Characteristics Curve low range pressure



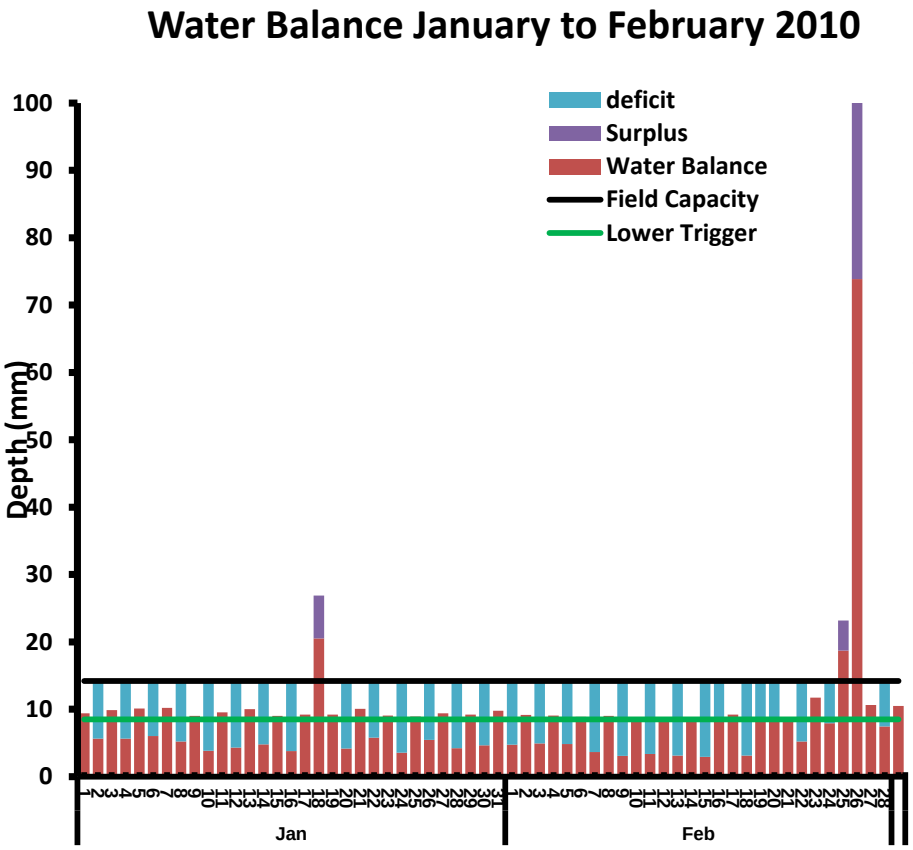
Pressure applied (bars)


St. Kitts - Water Balance Model Simulation Results- annual rainfall
mm of Water
2500
2000
1500
1000
500
0
-500
-1000
-1500
2005
2006
2007
2008
2009
2010
2011
2012
Rainfall
Surplus
Deficit
Etc

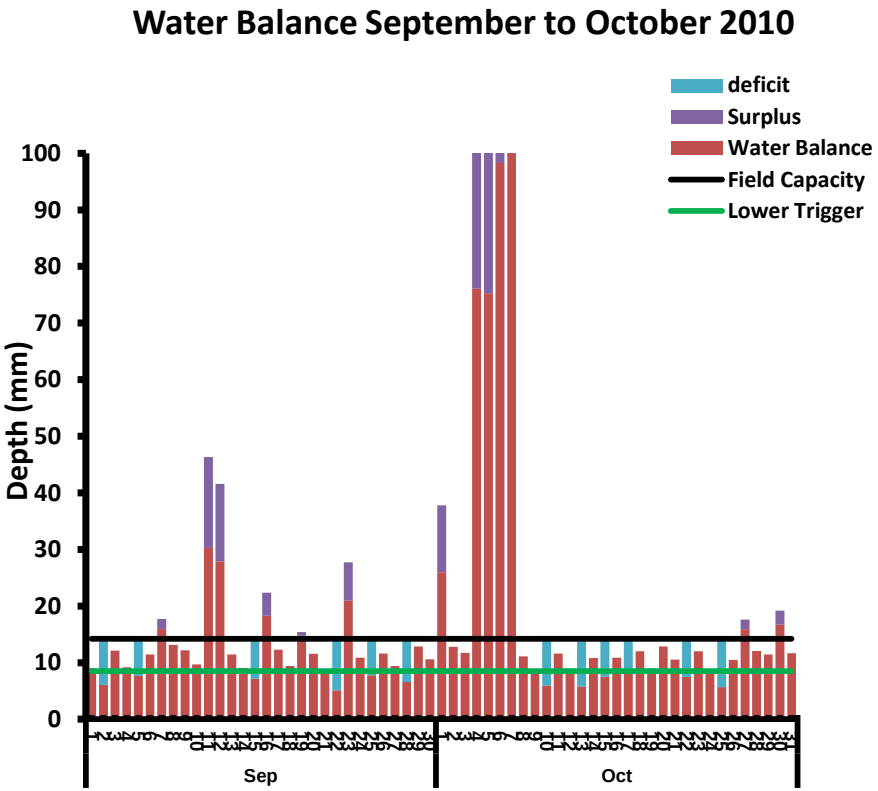
Parika - Water Balance Model Simulation Results – annual rainfall



St Kitts wettest year – 2010 – (1972 mm of Rainfall)

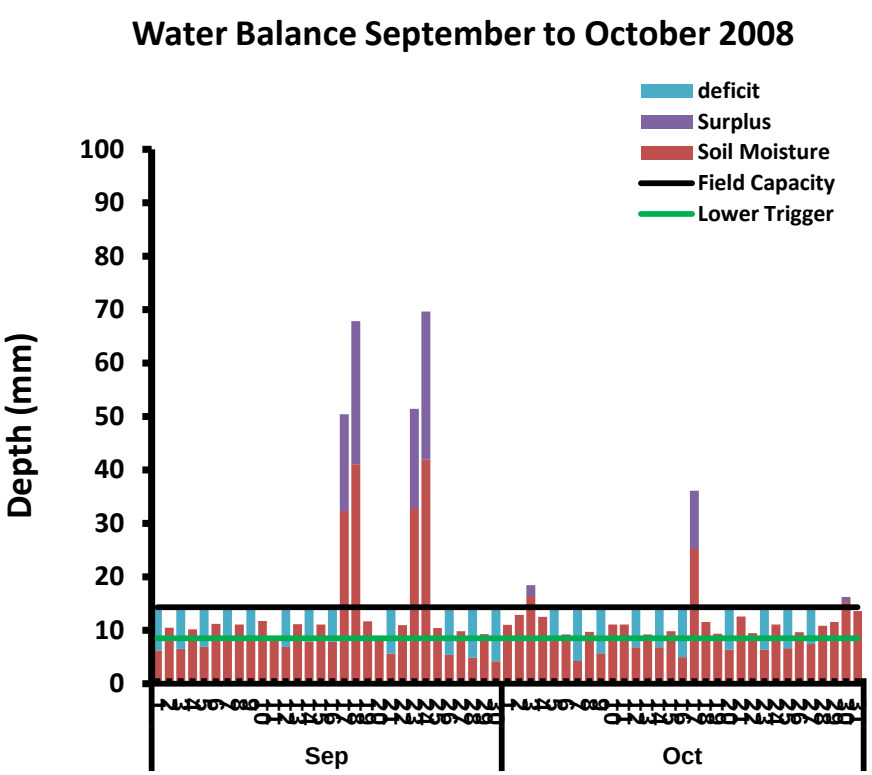


Driest month: January
Rainfall: 31 mm

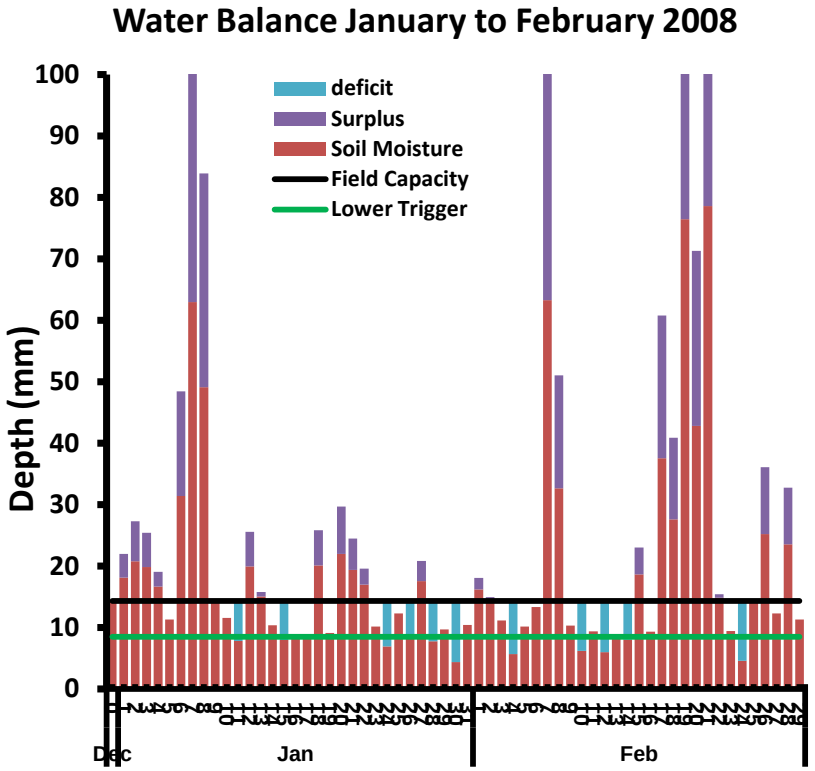


Wettest month: October
Rainfall: 384 mm

Parika - wettest year – 2008 (3520 mm of Rainfall)

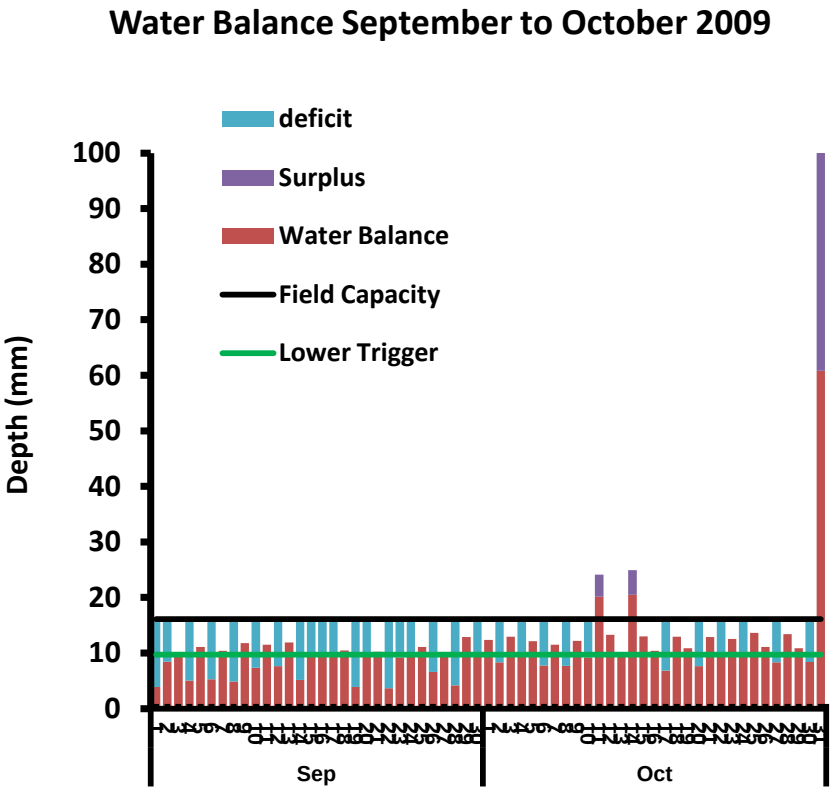


Driest month: October
Rainfall 59 mm

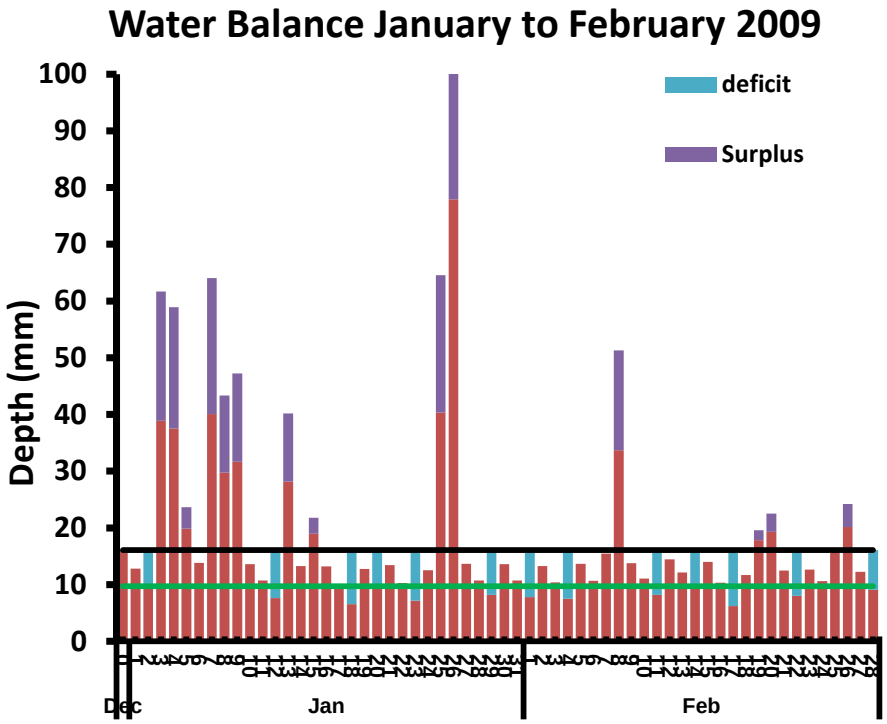


Wettest month: February
Rainfall 367 mm

Black Bush Polder - driest year – 2009 (1309 mm of Rainfall)

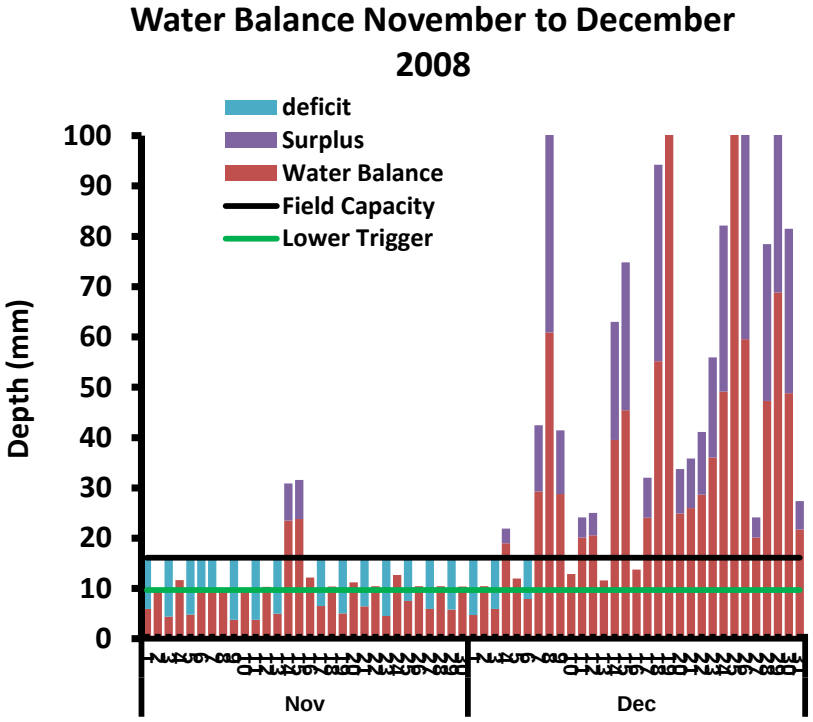


Driest month: September
Rainfall 8 mm

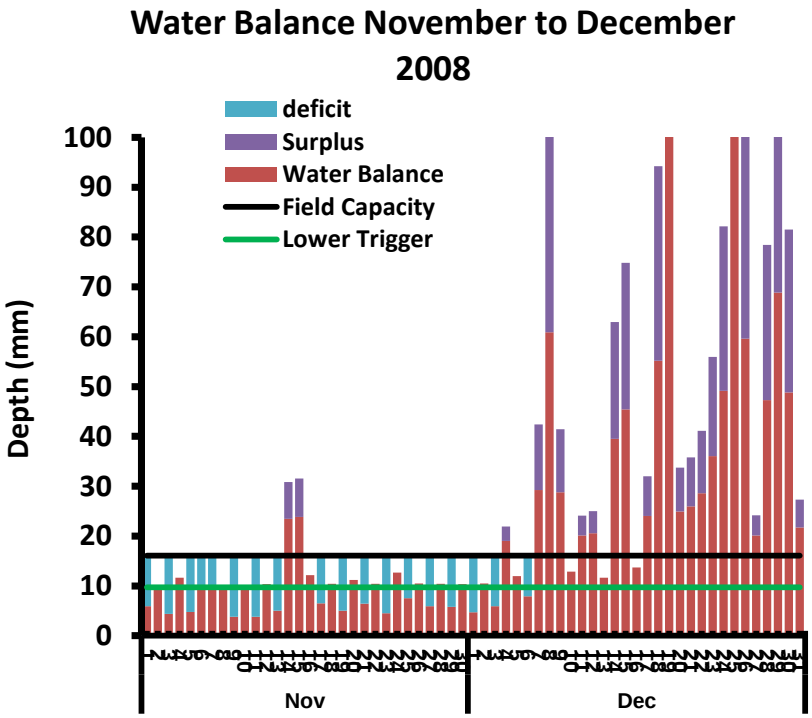


Wettest month: January
Rainfall 264 mm

Black Bush Polder - wettest year –2008 (2744 mm of Rainfall)

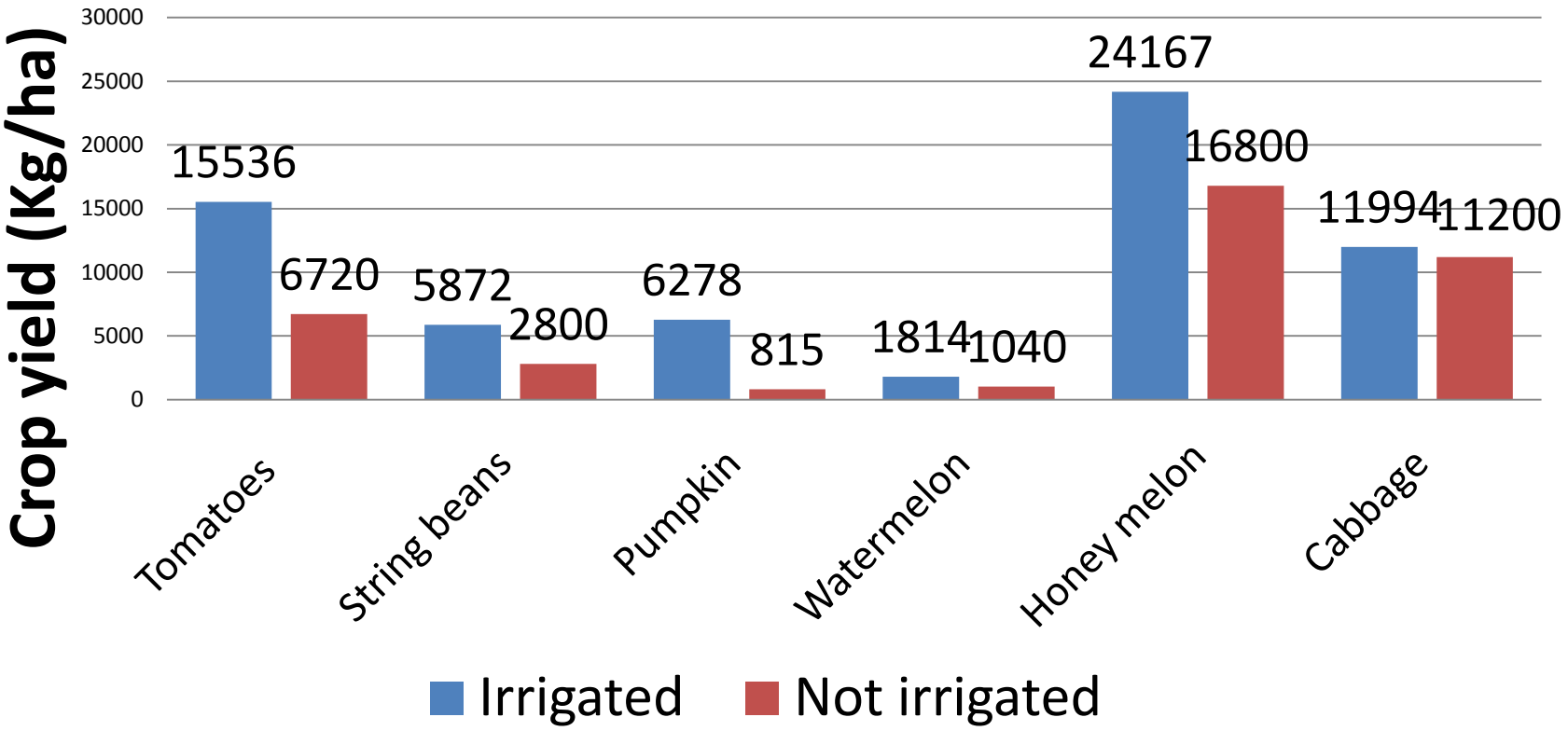


Driest month: November
Rainfall 33 mm

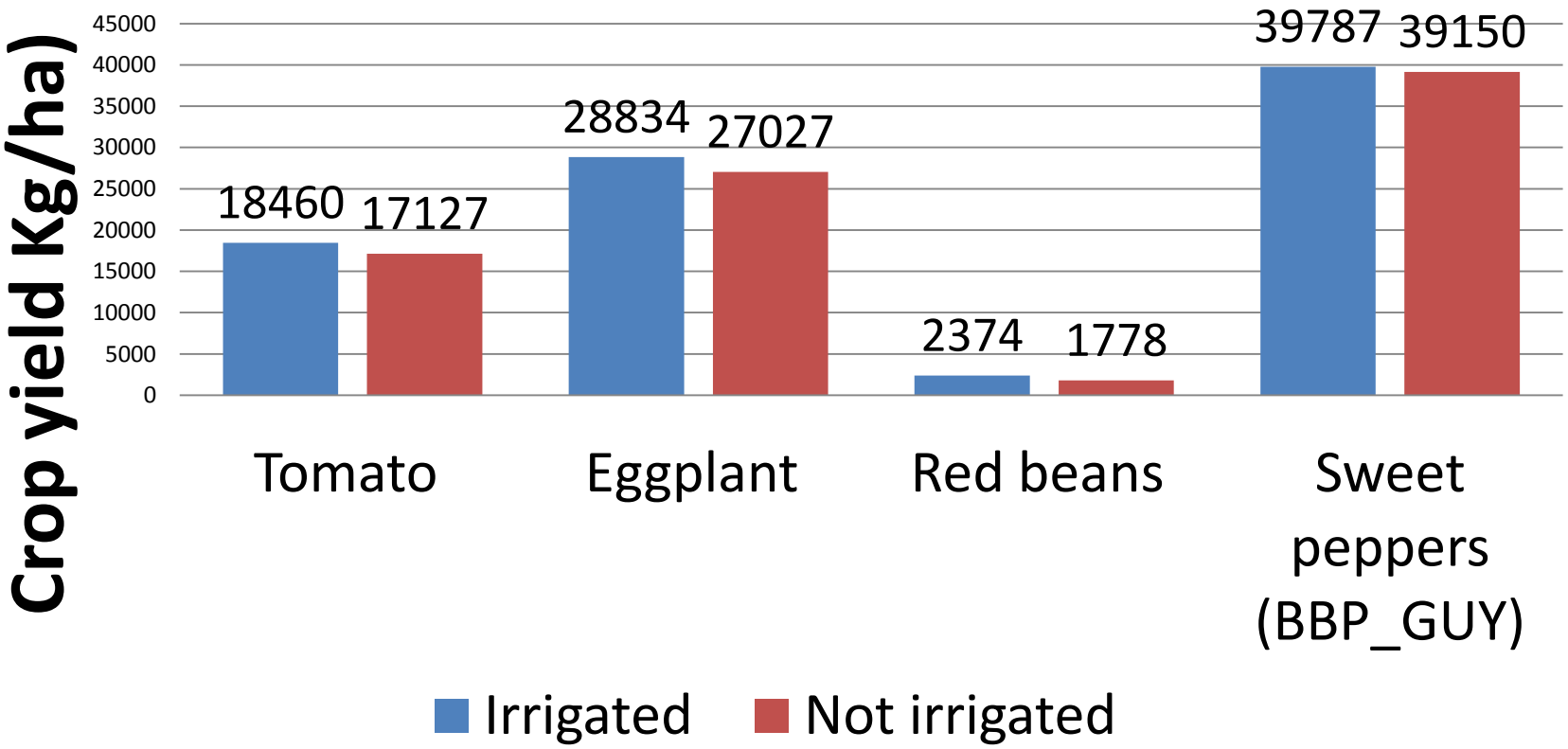


Wettest month: December
Rainfall 767 mm

St. Kitts - Crop Yields (Kg/ha)



Black Bush Polder - Crop Yields (Kg/ha)



Conclusions

- Drip irrigation significantly increased crop yields in St Kitts
- There was increased diversity in cropping systems and year crop production in St Kitts;
- This production was used to partially supply the dietary needs of the School Meals Program;
- Small farmers, particularly women, had increased incomes;
- Yield increases were not as significant in Guyana due to wetter soil conditions, heavier soil types and the rainfall patterns;
- Soil water simulation modelling enabled precise calculation of the daily crop water requirements, and is useful in explaining crop response to either soil water surpluses or deficits;
- Automated soil moisture sensors can support irrigation scheduling practices, provided the soil water holding capacity is known.

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Foreign Affairs, Trade and Development Canada
Affaires étrangères, Commerce et Développement Canada

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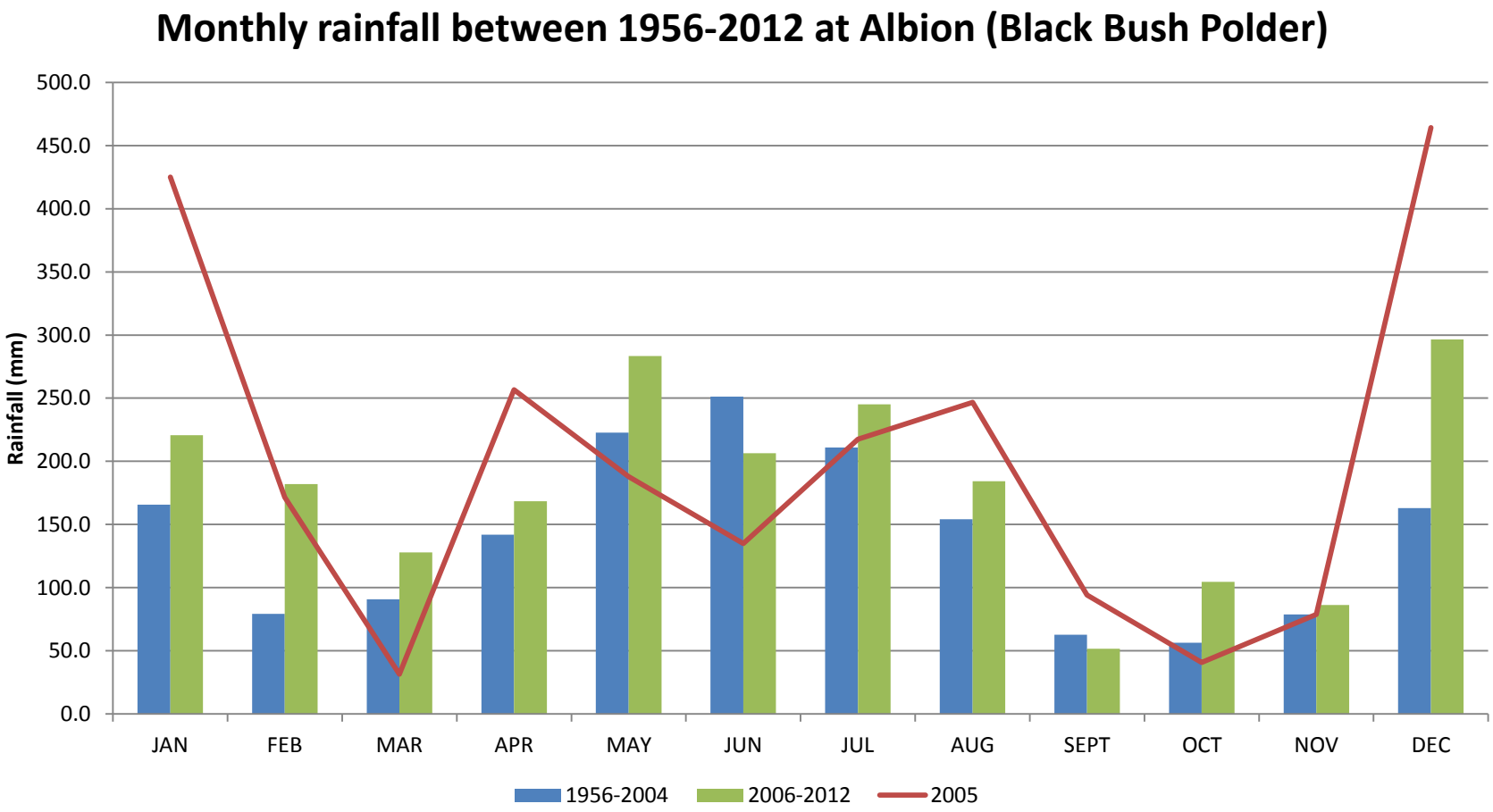
McGill
THANK YOU

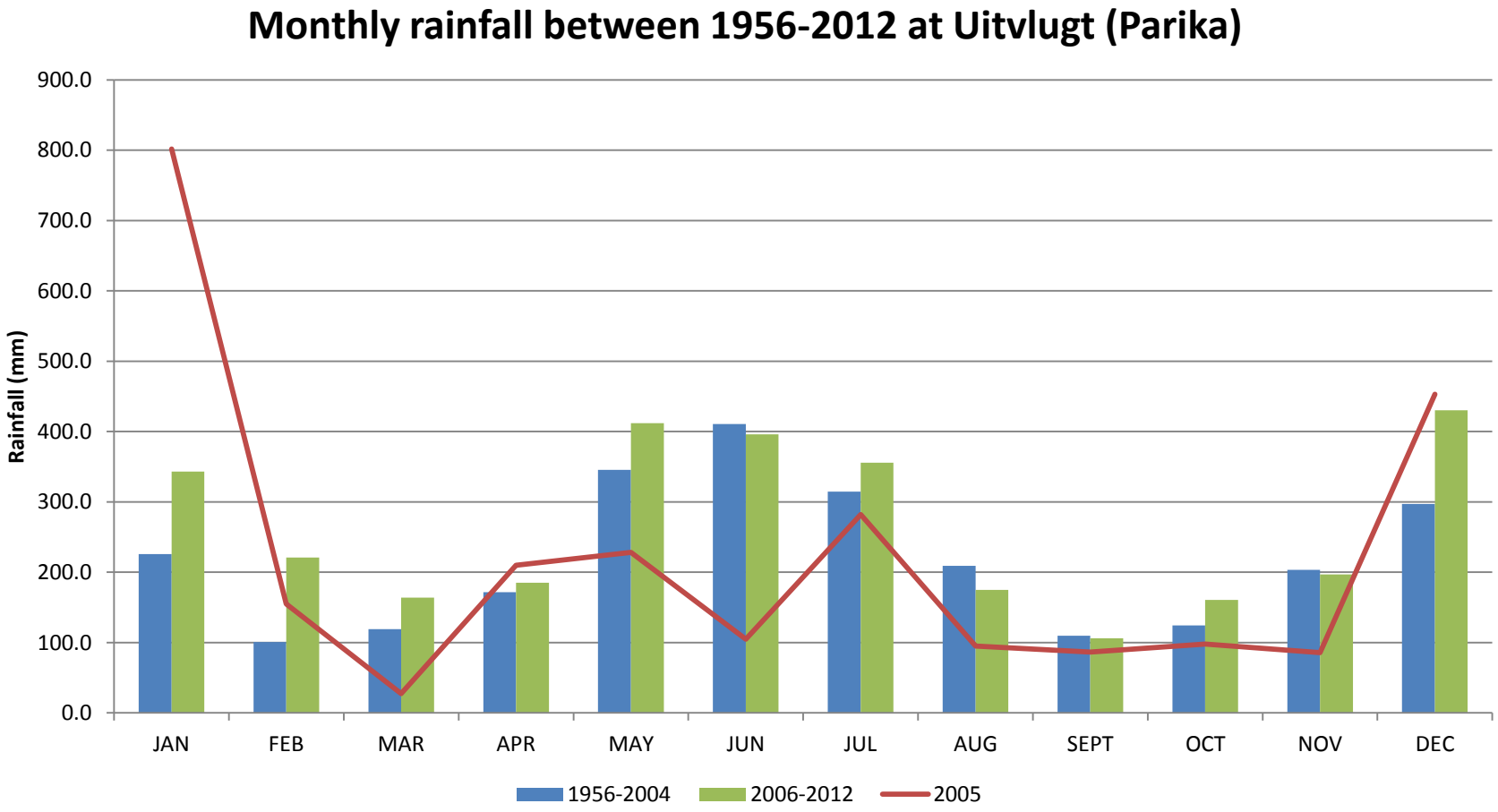
- By inputting climatological data into the soil water balance model (McGill-IRRIMOD©), the amount of irrigation water to be applied daily was calculated.
- Reff - Effective rainfall (mm) -rainfall lower than 5 mm is not considered as a effective rainfall.
- The trigger values for the irrigation scheduling simulation were based on soil water retention curve for each region.
- For the days when the combined soil moisture and rainfall exceeds Field Capacity the excess is considered as surface runoff. The computation of the soil moisture for the following day assumes that the soil was at field capacity the previous day.
- For the days when the combined soil moisture and rainfall is lower than trigger value (60% of AWC) , the lack of water is consider as a deficit. The computation of the soil moisture for the following day assumes that the soil was at field capacity on the previous day.

Sr. Kitts Water Balance Model – Annual values				
	Rainfall	Etc	Surplus	Deficit
	mm	mm	mm	mm
2005	1528	1133	1008	-941
2006	1433	1246	878	-983
2007	788	1151	381	-1049
2008	1090	1023	637	-891
2009	916	1023	479	-881
2010	1972	1040	1482	-853
2011	1589	961	1146	-803
2012	1468	1023	1024	-890

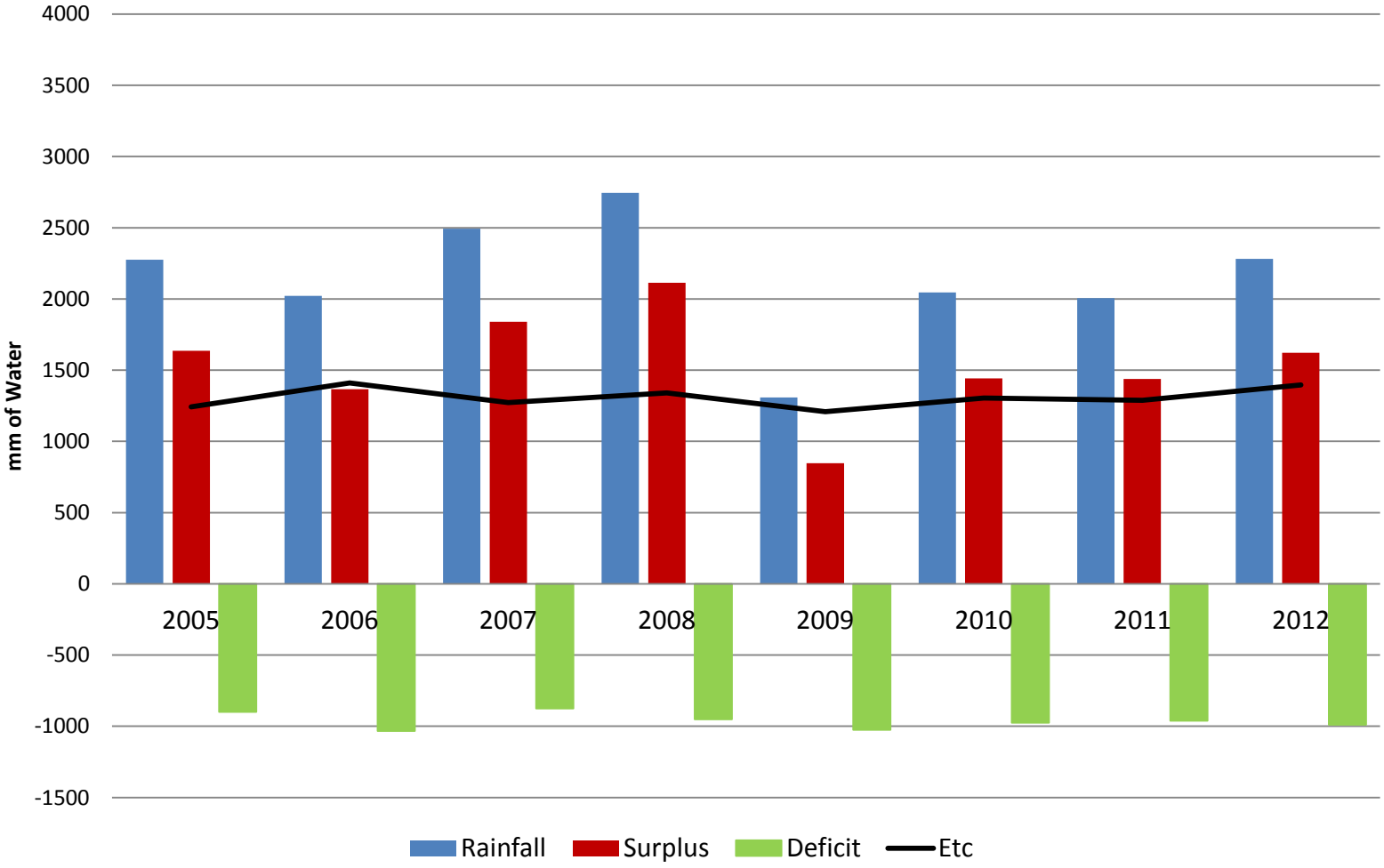
Parika (Guyana) Water Balance Model – Annual values				
	Rainfall	Etc	Surplus	Deficit
	mm	mm	mm	mm
2005	2560	1244	1917	-926
2006	3434	1410	2537	-793
2007	3199	1272	2487	-816
2008	3520	1339	2715	-760
2009	2272	1207	1657	-863
2010	3167	1303	2381	-817
2011	2832	1288	2116	-851
2012	3072	1216	2304	-714

Black Bush Polder (Guyana) Water Balance Model – Annual Values				
	Rainfall	Etc	Surplus	Deficit
	mm	mm	mm	mm
2005	2275	1243	1637	-900
2006	2022	1411	1365	-1033
2007	2494	1273	1841	-876
2008	2744	1339	2114	-951
2009	1309	1208	847	-1024
2010	2046	1304	1442	-976
2011	2005	1289	1437	-962
2012	2280	1397	1623	-989


Monthly rainfall between 1956-2012 at Albion (Black Bush Polder)
Rainfall (mm)
500.0
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV
DEC
1956-2004
2006-2012
2005

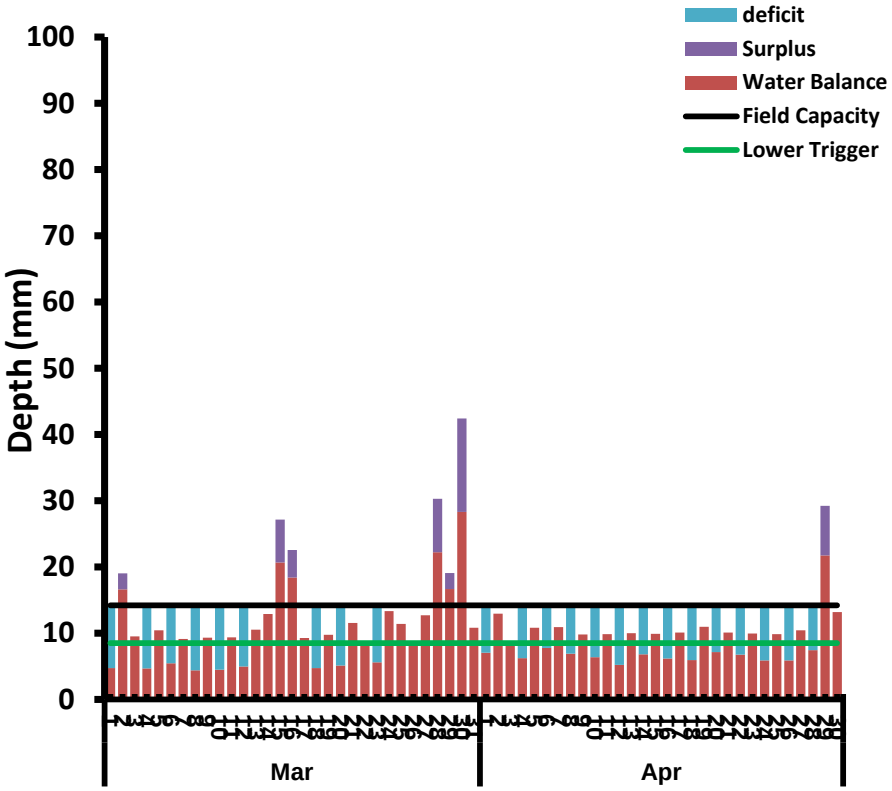

Monthly rainfall between 1956-2012 at Uitvlugt (Parika)
Rainfall (mm)
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV
DEC
1956-2004
2006-2012
2005

Black Bush Polder - Water Balance Model Simulation Results - annual rainfall



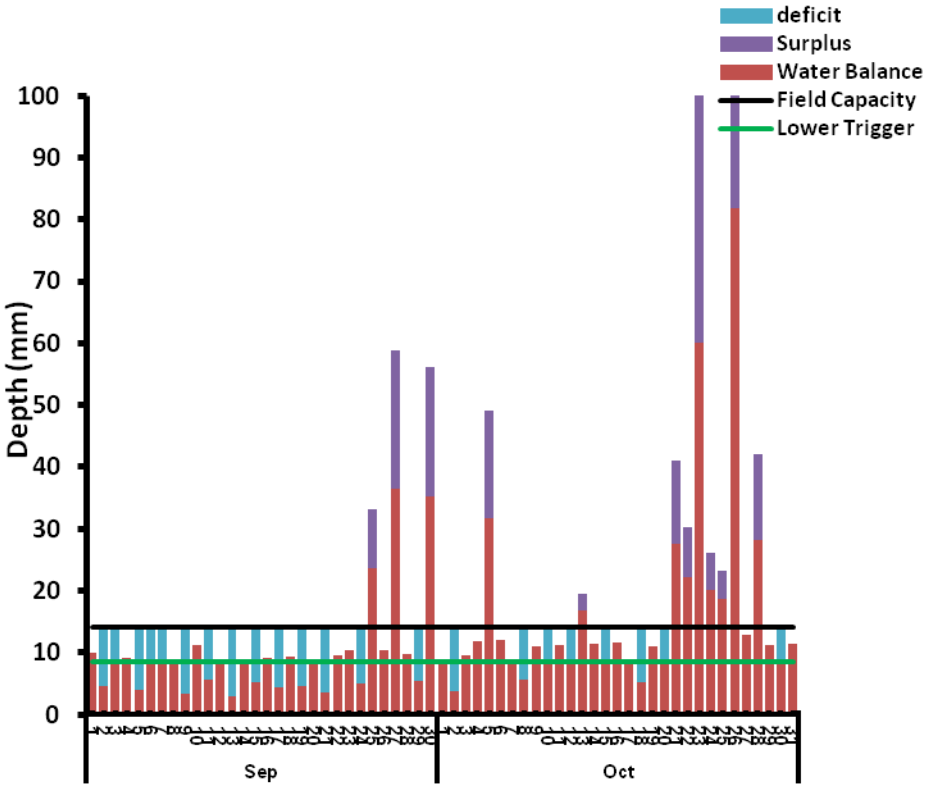
St. Kitts driest year – 2007 – (788 mm of Rainfall)

Water Balance March to April 2007



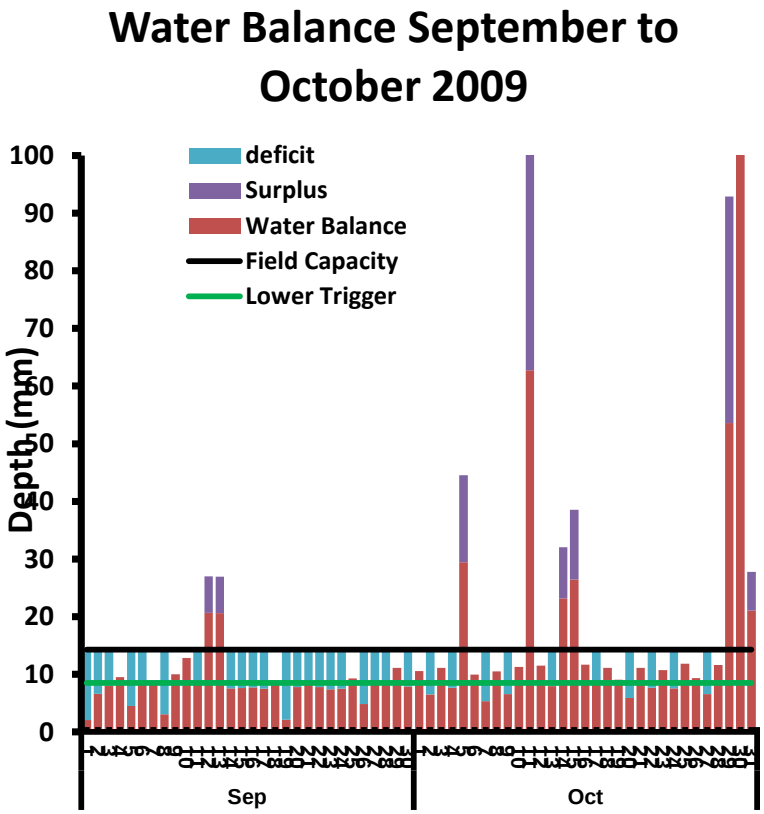
Driest month: April 2007
Rainfall 17.8 mm

Water Balance September to October 2007

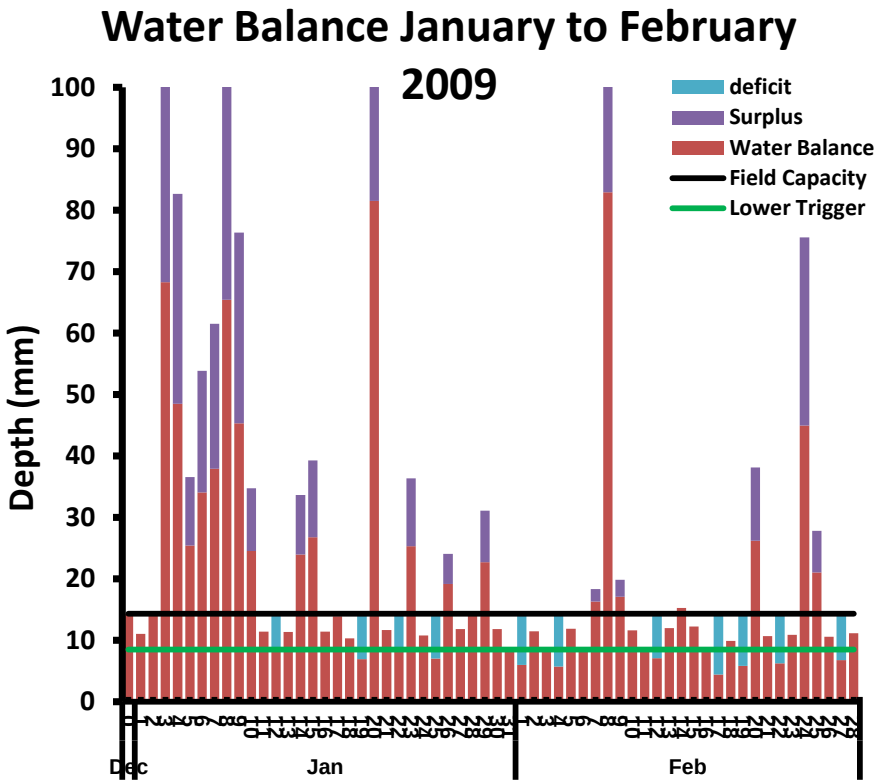


Wettest month in 2007:
October
Rainfall : 223 mm

Parika - driest year – 2009
(2272 mm of Rainfall)



Driest month: September
Rainfall 29 mm



Wettest month of year: January
Rainfall 432 mm