Water Use and Productivity of Sugarbeet and Sweet Sorghum

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Background

- The research forms part of a solicited research project (K5/1874 - Water use of cropping systems adapted to bio-climatic regions in South Africa and suitable for biofuel production) that was initiated by the Water Research Commission (WRC) of South Africa in KSA 4 (Water Utilisation in Agriculture).
- Funded by the WRC
- Co-funded by the Department of Agriculture, Forestry and Fisheries (DAFF).

Introduction

- The water use of biofuel crops is critical
- Crops which use less water and with high water use efficiency (water productivity)
- Water Productivity (WP) is defined as the amount of organic matter produced (tons per hectare) per unit amount of water used (mm or m^3)

Introduction

- Total evaporation can provide accurate estimates of water use
- The aim of this study was to estimate the WP of well watered sugarbeet and sweet sorghum with reference to biomass yield, biofuel yield and seasonal water use.

Crop and site details

- Sugarbeet (EB 0809 variety)
- Sweet sorghum (Sugargraze variety)
- Site: Ukulinga Research Farm (80 m x 80 m plots)
- Irrigation: drip (non-pressure compensating)
- Two growing seasons (2010/11 and 2011/2012)

Methods (Water use)

- The shortened energy balance equation:

$$R_n - H - G - \lambda E = 0$$

$$\lambda E \text{ (ET)} = R_n - H - G$$

Methods (Water use)

- **Sensible heat flux (H) was estimated using eddy covariance (EC) and surface renewal (SR) methods**
- **Soil Profile Water Content (TDR 100)**

Sugarbeet

Sweet Sorghum

Methods (Yield)

- Sample plots were used for the yield analysis
- Sugarbeet (tuber)
- Sweet sorghum (stalks, leaves and heads)
- Total soluble sugar content (%) was calculated from the Brix (%) using the Liu *et al*. (2008) method

Soluble sugar content (%) = 0.8111 * Brix (%) – 0.3728

Methods (Yield)

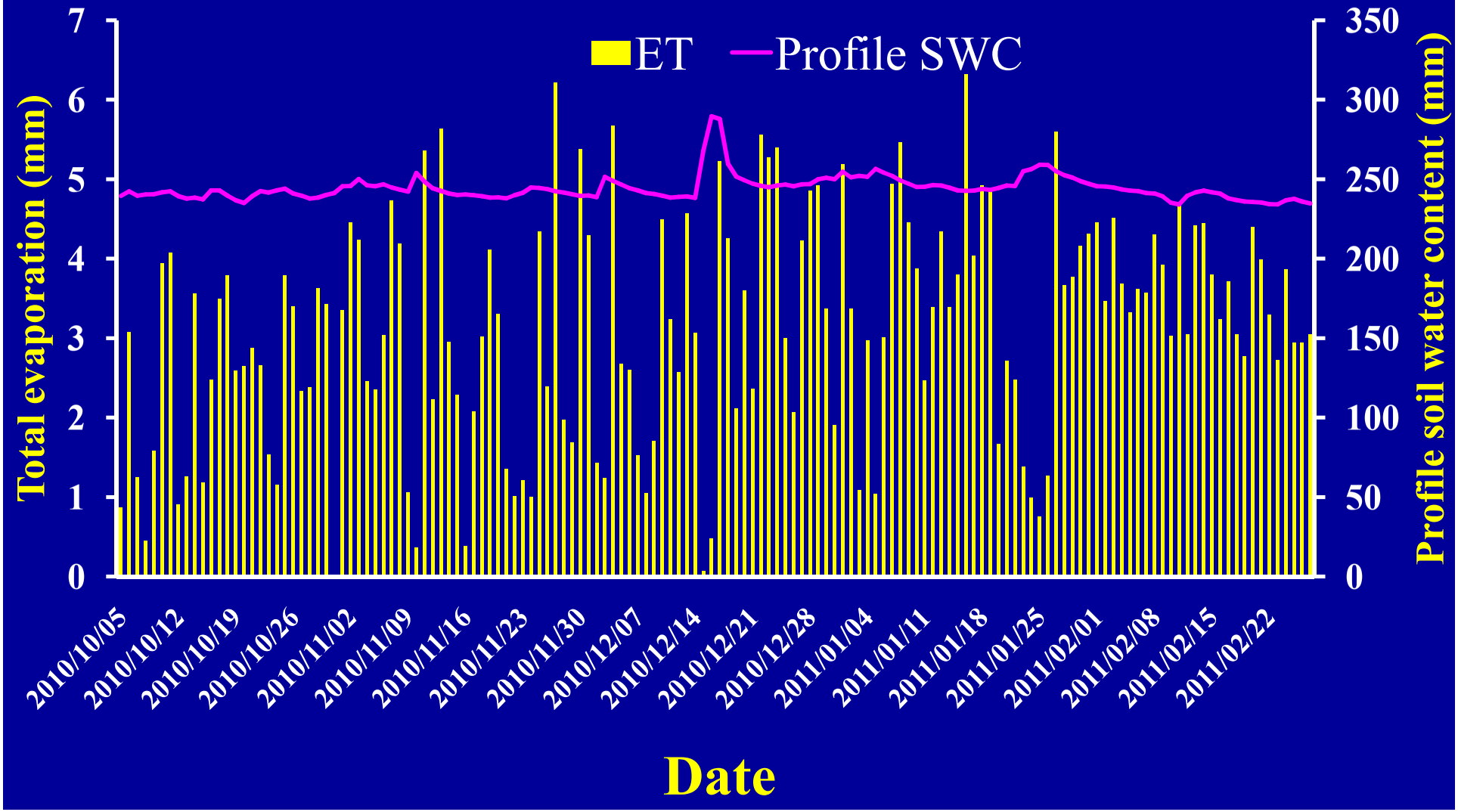
- One degree Brix (° Bx) is equivalent to 1 gram of sucrose in 100 grams of aqueous solution

- Ethanol production was calculated using the Vasilakoglou *et al*. (2011)

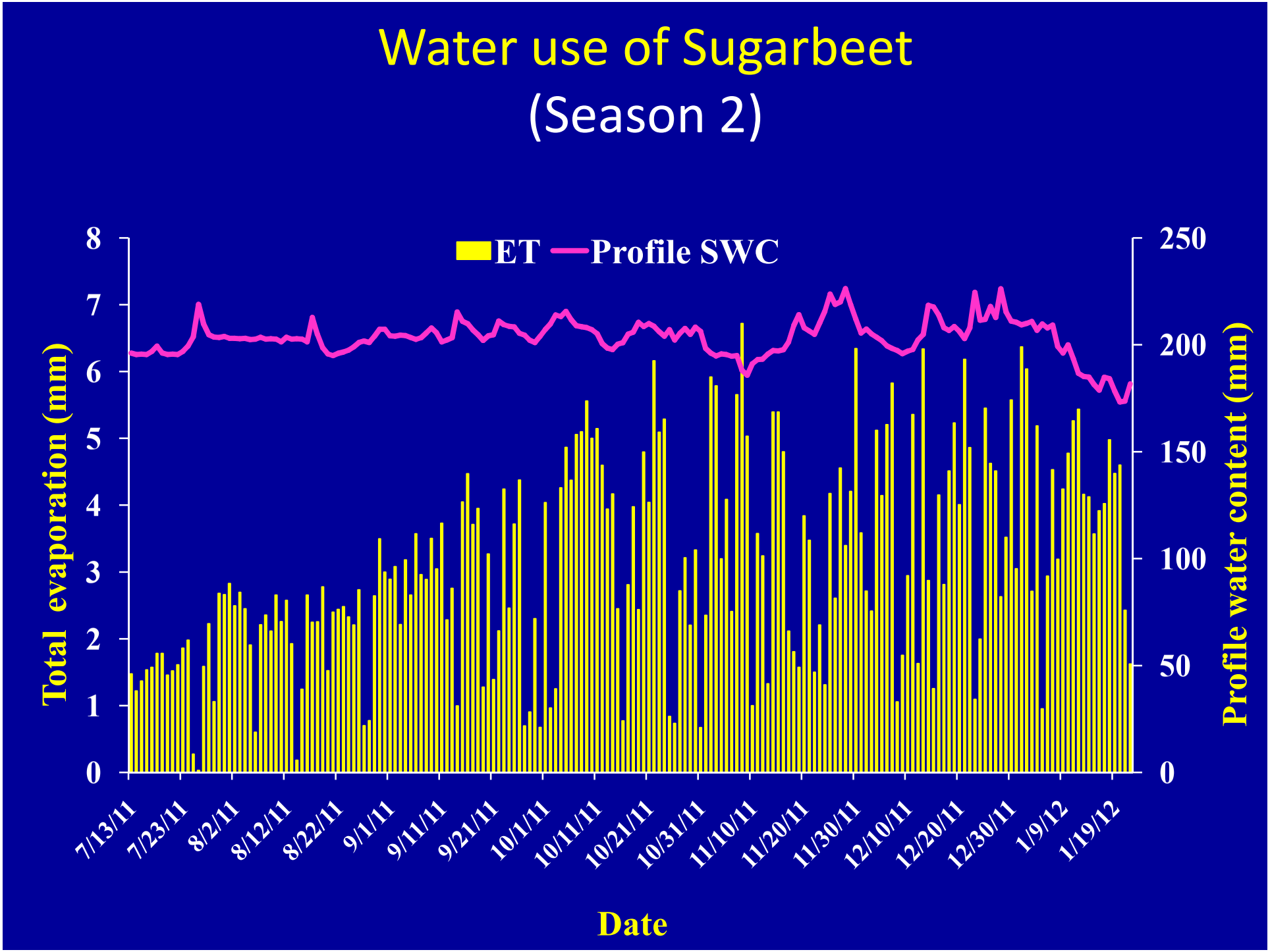
Total ethanol yield (L ha^{-1}) = Soluble sugar content (%) * Stalk fresh yield (t ha^{-1}) * 0.51 * 0.85 / 0.79

Results

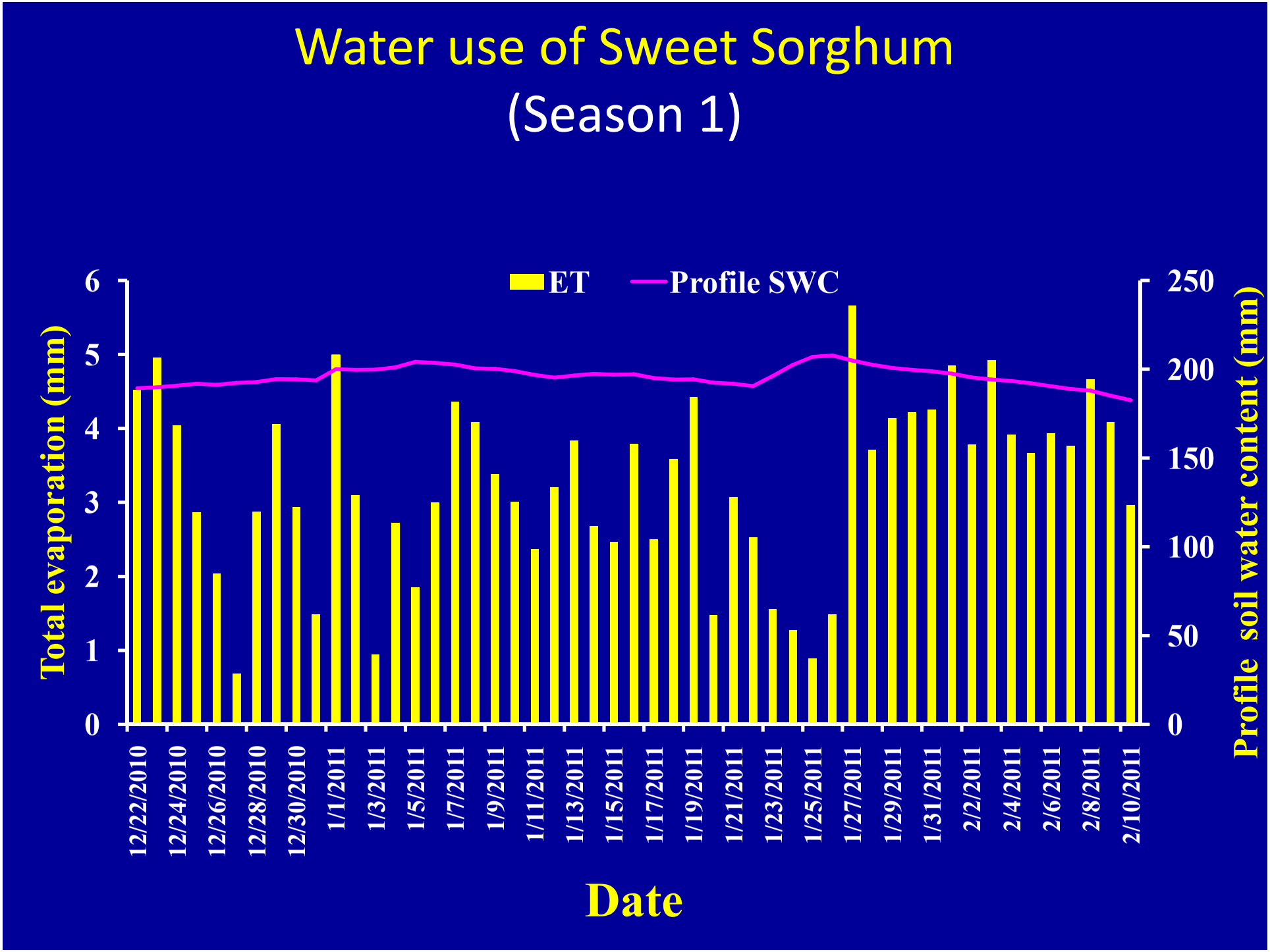
Water use of Sugarbeet (Season 1)



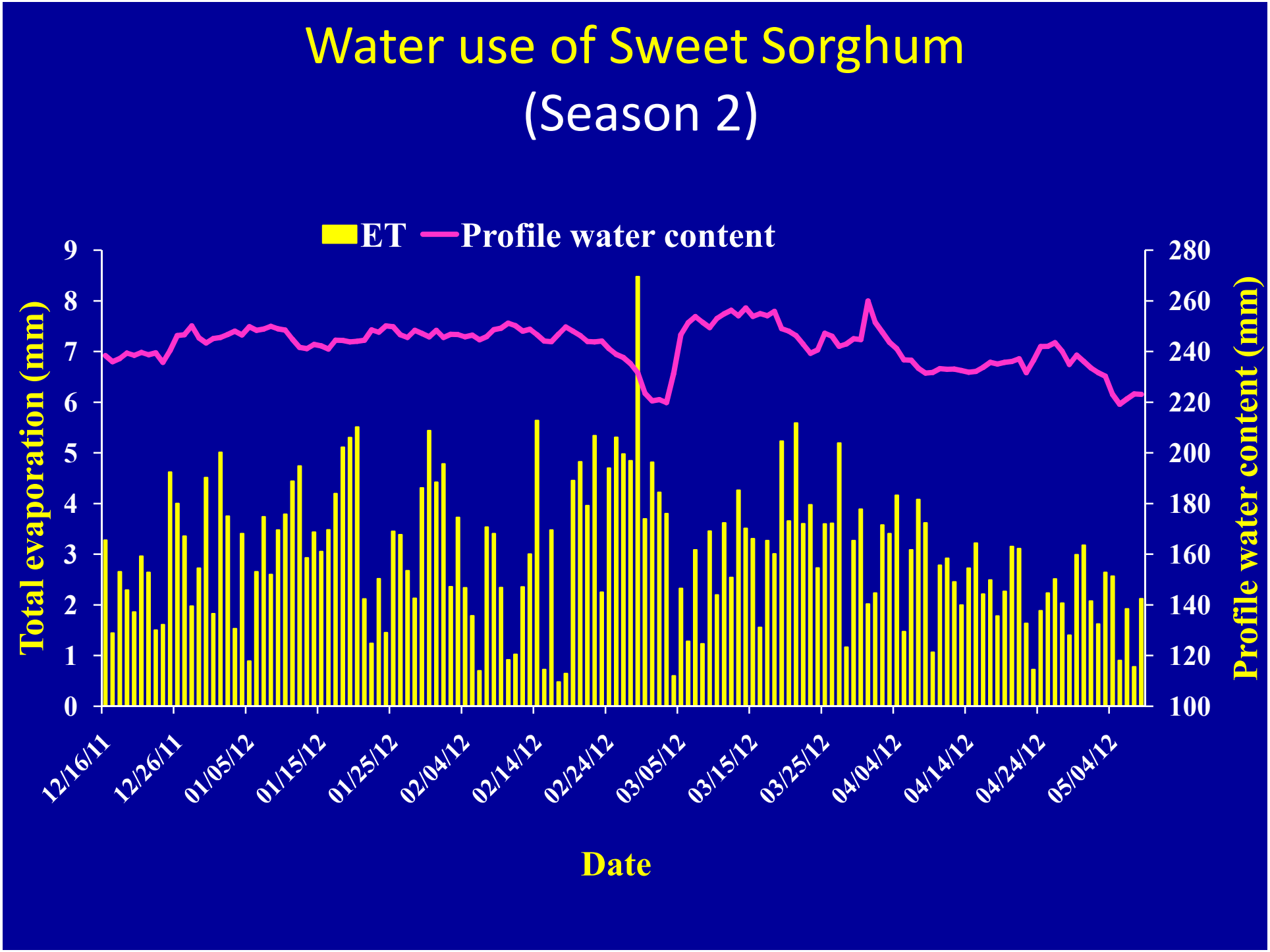
Water use of Sugarbeet (Season 2)



Water use of Sweet Sorghum (Season 1)



Water use of Sweet Sorghum (Season 2)



Summary of water use and yield (Sugarbeet)

Season	Growing period (days)	Water use (mm)	Water use (m^3 ha^{-1})	Tuber yield (t ha^{-1})	Sucrose (t ha^{-1})	Ethanol (L ha^{-1})
2010/11	181	562	5620	53.1	7.8	4021
2011/12	182	556	5560	21.7	3.7	1881

Summary of water use and yield (Sweet Sorghum)

Season	Growing period (days)	Water use (mm)	Water use (m^3 ha^{-1})	Fresh stalk (t ha^{-1})	Dry stalk (t ha^{-1})	Sucrose (t ha^{-1})	Ethanol (L ha^{-1})
2010/11	132	394	3940	24.4	4.89	2.2	924
2011/12	145	436	4360	41.8	9.37	5.2	2271

Water Productivity
(Sugarbeet)

Season	$WP_{Tuber\ yield}$ (kg m^{-3})	$WP_{Sucrose}$ (kg m^{-3})	$WP_{Ethanol}$ (L m^{-3})
2010/11	9.44	1.40	0.72
2011/12	3.91	0.66	0.34

Water Productivity
(Sweet Sorghum)

Season	WP_{TDM} (kg m^{-3})	$WP_{Fresh\ stalk}$ (kg m^{-3})	$WP_{Dry\ stalk}$ (kg m^{-3})	$WP_{Sucrose}$ (kg m^{-3})	$WP_{Ethanol}$ (L m^{-3})
2010/11	1.68	6.20	1.24	0.56	0.23
2011/12	3.01	9.59	2.15	1.20	0.52

Conclusion

- WP is influenced by many factors:
  - genotype of the crop
  - climatic conditions
  - irrigation management
  - planting density
  - fertiliser application
  - agronomic practices.

Conclusion

- Sugarbeet shows much potential as a water use efficient biofuel feedstock.
- Further agronomic research is required to best manage disease and weed problems.

Acknowledgment

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