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Validation of Accurate Determination of Maize Water Requirements in Nile Delta

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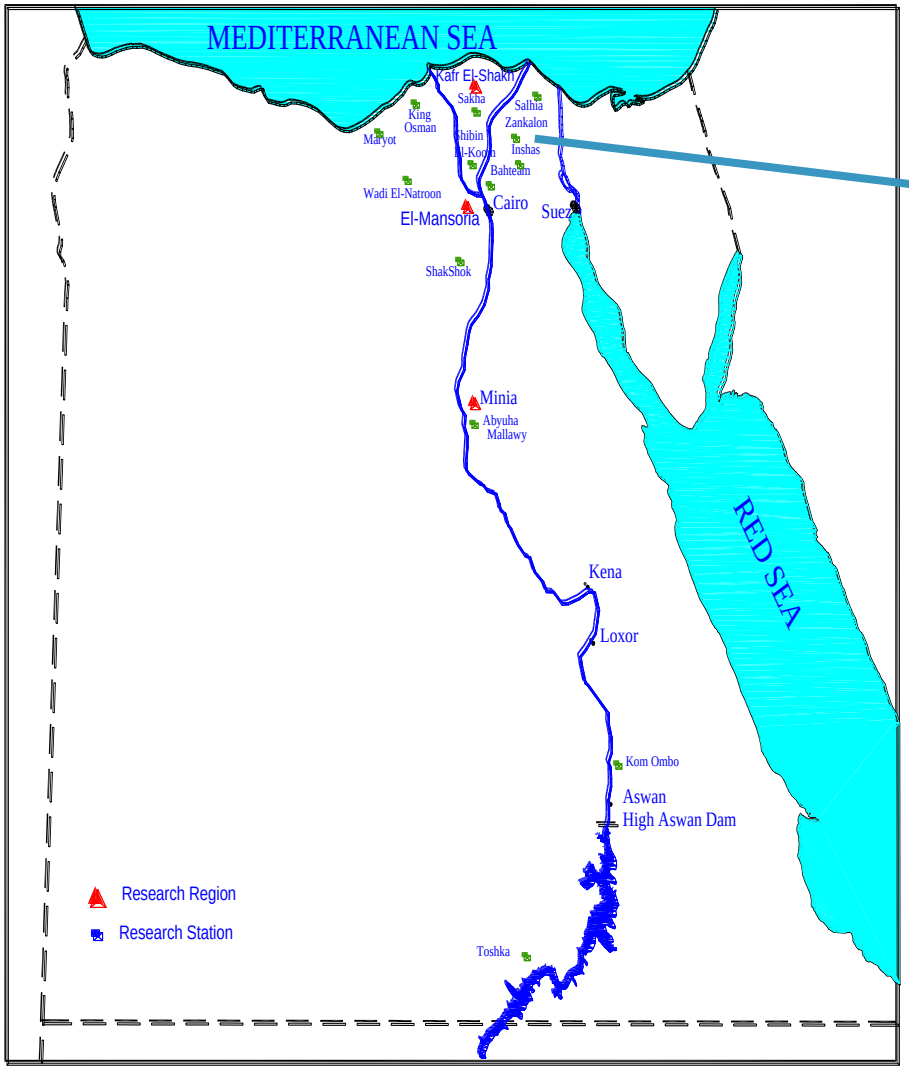
1. INTRODUCTION

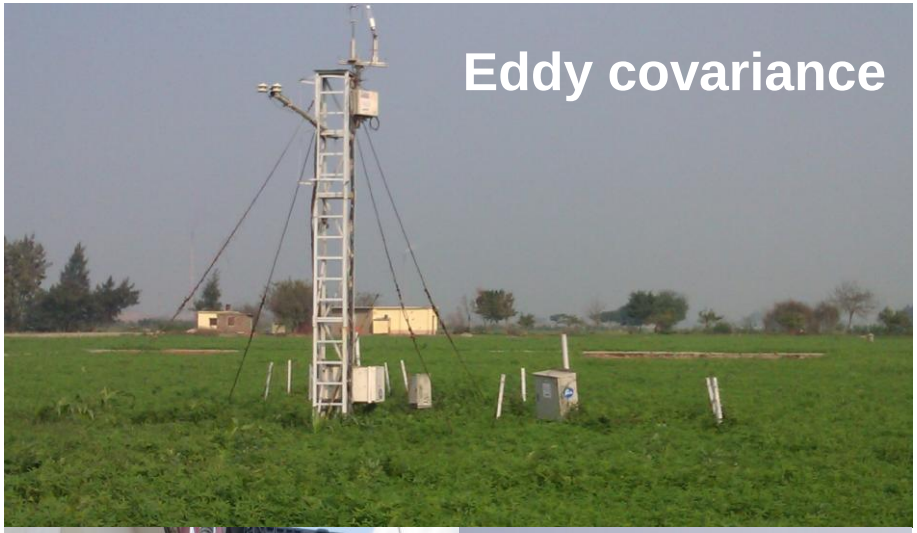
- In Egypt, maize is one of the most important cereal crops. It is a summer feeding crop for human consumption, animal and industrial purpose especially for oil production. However, there is a gap between the local production and consumption of maize.
- Agriculture sector in Egypt consumes a huge amount of the total available water about 85% (Abu-Zied, M., 1999).
- FAO-56 have served as widely used source for crop coefficients. The approach is to derive the actual evapotranspiration ETc by the product of a crop dependent coefficient (crop coefficient) Kc and a climate reference evapotranspiration (ETo).
- Recently, the eddy covariance technique is particularly adapted as studying ecosystem physiology.
- The combination of soil and canopy heat storage and the energy used in photosynthesis of crops need to be considered for an accurate estimation of the energy balance.
- **The objective is to summarize the results of the maize evapotranspiration and crop coefficients derived from weighing lysimeter and eddy covariance methods. A comparison will include evapotranspiration from Modified Penman-Monteith equation.**

2. MATERIALS AND METHODS



This study was conducted in Zankalon Water Requirements Experimental Station, Water Management Research Institute, National Water Research Center, Egypt. The site is located at 30° 35' N and 31° 30' E with an elevation of about 7 meters above sea level. All agricultural operations were the same for all treatments.

2. Materials and Methods



The eddy covariance technique is a key atmospheric measurement technique to measure and calculate vertical turbulent fluxes within atmospheric boundary layers. The technique is mathematically complex, and requires significant care in setting up and processing data.

Eddy covariance (EC) can measure the exchange of water vapor, energy and carbon dioxide between the earth's surface and atmosphere directly, and has been used widely in the world.

2. Materials and Methods

The lysimeter tank containing the soil under measurement of (2 m × 4 m) surface area and 2 m depth. Lysimeter in its simplest form involves the volumetric measurement of all incoming and outgoing water of a container.

The lysimeter used in this experiment is classified as a weighing lysimeter and has been constructed and installed by precision lysimeter Inc. (Red Bluff, CA, USA).

2. MATERIALS AND METHODS

3. RESULT AND DISCUSSION

I. Evapotranspiration estimation and validation

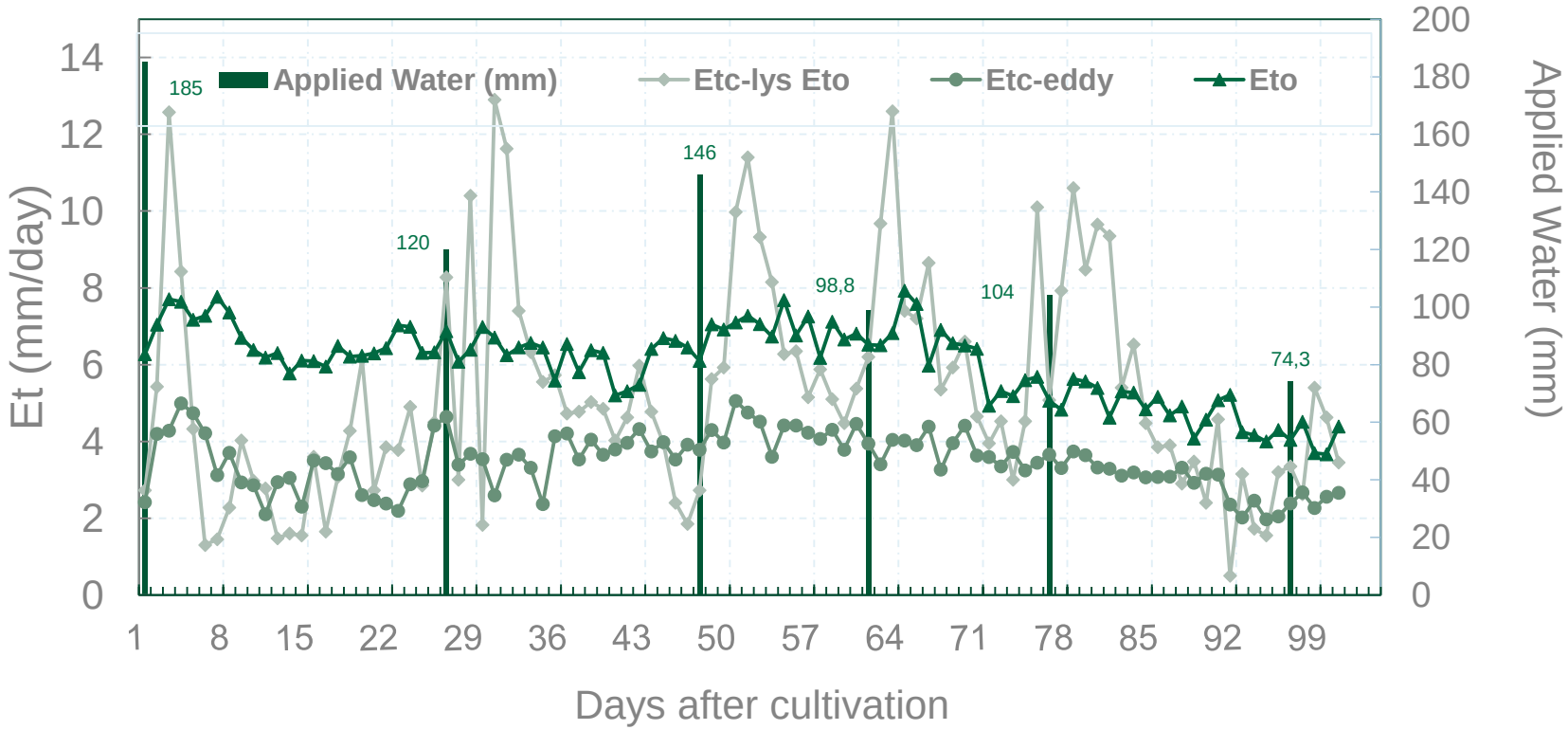


Figure (1): Crop evapotranspiration for two different methods compared with reference evapotranspiration and applied water

3. RESULT AND DISCUSSION

Polynomial equations used to explain the obtained results from each method as follow:

To identify ET using eddy covariance method:

$ET_{eddy} = -1E\text{-}05x^3 + 0.0016x^2 - 0.0378x + 3.5902$, ($R^2 = 0.4322$)..... (1)

To identify ET using lysimeter method:

$ET_{lys} = -3E\text{-}05x^3 + 0.0035x^2 - 0.0562x + 4.3448$, ($R^2 = 0.1791$)..... (2)

To identify Modified Penman-Monteith method:

$ET_{PM} = -1E\text{-}05x^3 + 0.0017x^2 - 0.0617x + 7.1451$, ($R^2 = 0.6919$)..... (3)

The correlation values of each methodology shows that the Modified Penman-Monteith still the most reliable methodology to depend on followed by eddy covariance method for maize crop in the study area.

Lysimeter shows a very low correlation. This mainly due to the applied water fluctuated according to growth stages as well as soil moisture content.

3. RESULT AND DISCUSSION

Growth stages and evapotranspiration

The reference evapotranspiration gradually decreases during the crop growth, it depends on the climatic conditions not the crop itself. The crop evapotranspiration for both methods (eddy covariance and lysimeter) are gradually increase with the growth stages until reach the maximum at flowering stage and decrease during the late stage (harvesting time).

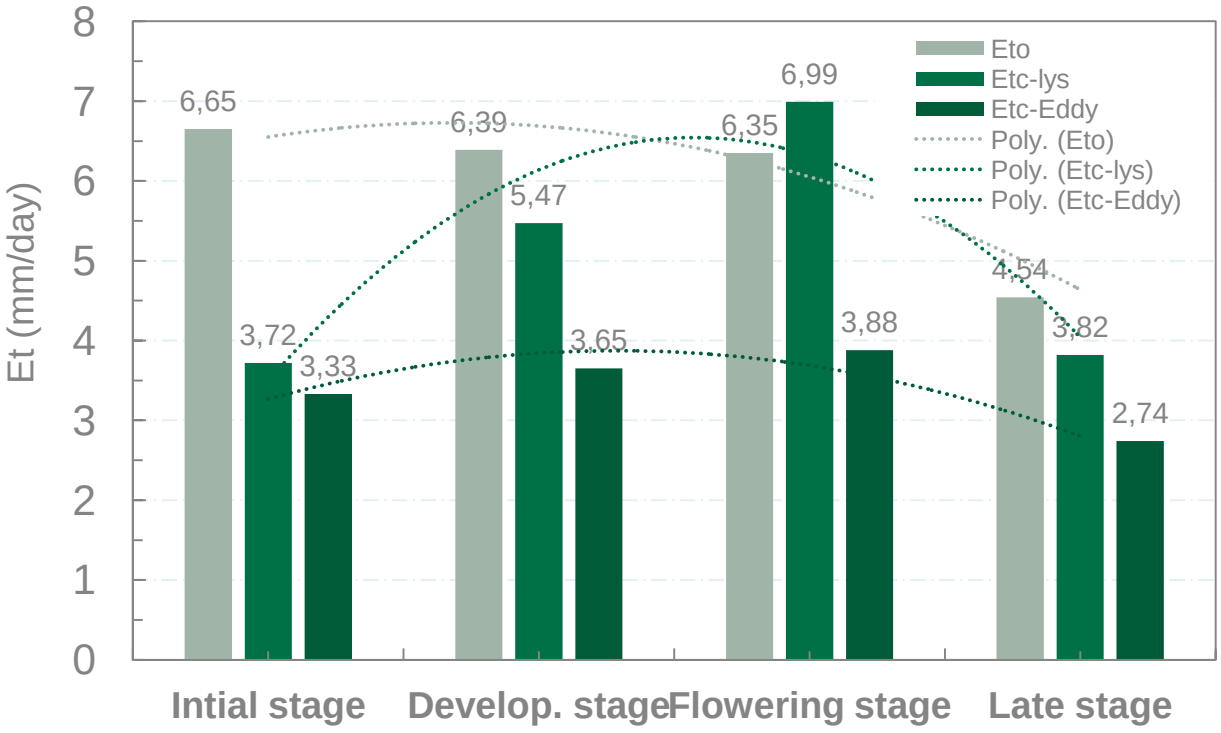


Figure (2): crop evapotranspiration for maize crop growth stages

3. RESULT AND DISCUSSION

Polynomial equations used to explain the effect of growth stages of maize on evapotranspiration trend for each studied method as follow:

To identify ET using eddy covariance method:

$ET_{eddy} = -0.365x^2 + 1.671x + 1.96, \quad (R^2 = 0.888)\ldots\ldots\ldots (4)$

To identify ET using lysimeter method:

$ET_{lys} = -1.23x^2 + 6.332x - 1.605, \quad (R^2 = 0.862)\ldots\ldots\ldots (5)$

To identify Modified Penman-Monteith method:

$ET_{PM} = -0.3875x^2 + 1.3005x + 5.6375, \quad (R^2 = 0.930)\ldots\ldots\ldots (6)$

Theoretically, the Modified Penman-Monteith still the higher correlation value 0.93.

Practically, depending on growth stages, both of eddy covariance and lysimeter methodologies have almost the same correlation value.

3. RESULT AND DISCUSSION

Crop coefficient

Figure 3 and Table 1 shows crop coefficient in different stages of maize growth using different methodologies (eddy covariance and lysimeter.

Flowering stage recorded the highest values of crop coefficient compared with other growth stages in different methods.

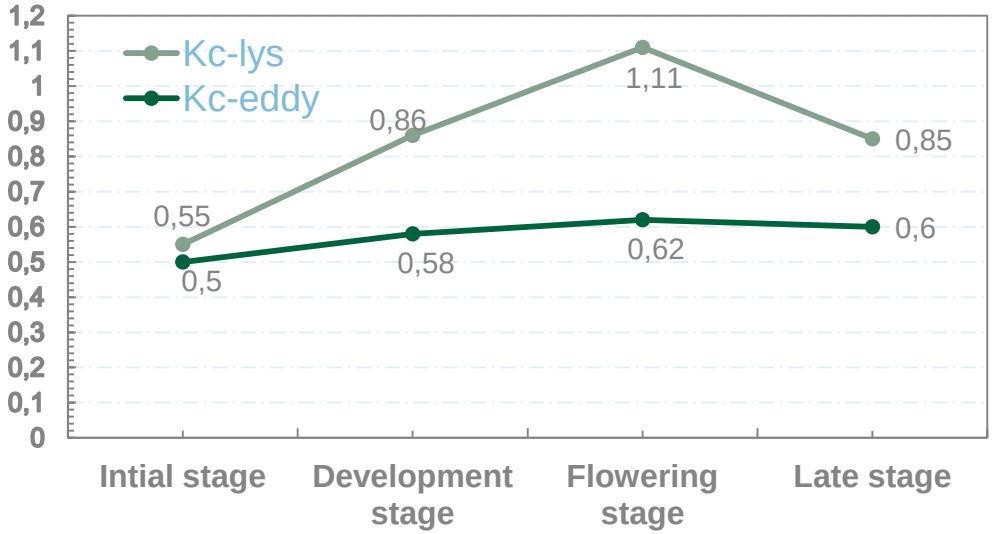


Figure (3): Average monthly Kc for two different cultivation methods

Table (1): Maize crop water requirements according to FAO-Kc in the study area

Months	June	July	Aug.	Sept.	Ave. water requirements (mm/day)
ET0 (mm/day)	7.13	6.28	6.65	4.77	
Growth stages	Initial	Mid-season		Late season	
Kc per gr. St.	0.6	1.2	1.2	0.6	
Kc per month	0.6	1.2	1.2	0.6	
ET crop (mm/day)	4.3	3.8	8.0	2.9	4.7
ET crop (mm/month)	128.3	113.0	239.5	85.8	141.7

4. Conclusions

- Among different methodologies to estimate reference evapotranspiration, Modified Penman-Monteith equation as a reference value, weighting lysimeter and eddy covariance technique methods used as a precision techniques.

- The obtained results showed that the eddy covariance is the most reliable methodology to measure actual evapotranspiration for maize in the region.

- As influenced by growth stages, eddy covariance and lysimeter methodologies could be used to find out maize crop evapotranspiration.

- Also, crop coefficients is depending on how the evapotranspiration data has been calculated or obtained.

- Lysimeter shows a very low correlation and sharply fluctuated data. Therefore, a recommendation for further validation and studies among the studied methodologies for the main crops of different agro-climatological regions of the country due to shortage of water resources.

Acknowledgment

The authors acknowledge:

JST-JICA to provide Eddy Covariance system.

Also, this research was partially supported through the ACIAR project “LWR/2011/045, Management of water and salinity in the Nile Delta; a cross-scale integrated analysis of efficiency and equity issues”. The authors greatly acknowledge the financial support from ACIAR


THANK YOU