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DETERMINATION OF CROP CO-EFFICIENT OF HYBRID MAIZE BY LYSIMETER STUDY

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Abstract

In a study at Joydebpur, the crop co-efficient values at initial, development, mid-season, and late season stages of hybrid maize (variety: BARI Hybrid Maize-I) were determined as 0.38, 0.87, 1.36, and 0.75, respectively. These locally determined values of BARI Hybrid Maize-I differed to some extent from those recommended by FAO. The corresponding FAO values are 0.4, 0.80, 1.15, and 0.70. The reasons might be that the FAO values are the generalized ones and recommended for a wide range of locations. But those determined by this study are location specific. Another reason may be the use of specific variety of hybrid maize in this experiment. However, locally determined values are preferred to standard values (FAO values) to estimate location specific crop ET.

Keywords : Crop co-efficient, hybrid maize, lysimeter.

Introduction

Crop co-efficient (K_c) is the ratio of the actual crop evapotranspiration (ET_c) to potential evapotranspiration (ET_o) i.e., $K_c = ET_c / ET_o$

Crop co-efficient values are required for estimating crop evapotranspiration (crop water requirement). It is cumbersome to determine the water requirements of a particular variety of crop in different places by setting experiment every time. Rather, it is much easier to estimate crop evapotranspiration to a large degree of accuracy. Values of K_c are available in literature (Doorenbos and Pruitt., 1977), but none is recommended for a specific location. Also, the values can be estimated from the standard values by adjusting a number of factors like temperature, humidity, irrigation sequences, soil textures, etc. (Allen *et al.*, 1998), but for more accuracy, it is better to determine the factors locally. Physiological characteristics of crop varieties differ under different soil and climatic conditions, thus, showing varying physiological demands including crop water requirements (Crop ET). The determination of crop co-efficient lies in the determination of stage wise crop ET and estimation of reference crop evapotranspiration. The most reliable method for determining the crop co-efficient values is the lysimetric study. Many researchers have studied crop ET using lysimeters (Khan *et al.*, 1992). Climatological approaches of estimating ET are available in literature (Doorenbos and Pruitt, 1977; Hensen *et al.*, 1979;. Burman *et al.*, 1983; Ben-Asher *et al.*, 1983, and Michael, 1978). These approches are empirical to varying extent and require local calibration which are impossible without lysimeters. So, this experiment was conducted to determine the crop co-efficient values of hybrid maize using micro lysimeter.

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Materials and Method

The micro-lysimeter is situated at BARI farm, Gazipur. It has four tanks spaced at equal distances (4 m) in a line. The lysimeter tank has 1 meter square area with effective soil depth of 100 cm followed by 2cm thick sand pack. Below the sand layer, 3 meshes of no. 4, 20, and 40 are placed. Below the mesh, a 13 cm thick gravel pack collects the excess water from the upper parts and discharges it to the drainage collector placed in the working chamber through a drainage pipe. The chamber is at a distance of 12 m from the remote tanks and 10 m from the nearest tanks.

Each lysimeter tank is provided with a GI pipe of 1.75 cm diamter which serves as an air vent. The vent is inserted upto the gravel layer and is provided with a cap at the top end. Below the gravel pack, a 7.5 cm thick concrete layer is provided followed by a 7.5 m thick brick soling. A 13 cm thick brick wall is constructed around the lysimeter tank leaving 5 cm sand pack between the tank and the wall. The brick wall is constructed at a depth of 20 cm from the soil surface (Fig. 1). For more details, please refer to Khan *et al*. (1992).

Maize (variety: BARI Hybrid Maize-I) was sown in four lysimeter tanks, each having 1 m^2 area on 29 November 2002. Also, to maintain a similar environment, the same crop was grown in the lands surrounding the tanks. The soil was silty clay loam with field capacity and bulk density, 28% and 1.5 g/cc, respectively. The selected treatments were,

T_1= Irrigation at 10 days interval

T_2= Irrigation at 15 days interval

T_3= Irrigation at 20 days interval

T_4= Irrigation at 25 days interval

Since, the micro-lysimeter had only 4 tanks, no replication of the treatments was possible. Climatic data, such as maximum and minimum temperatures, air humidity, sunshine hours/day and wind speed were collected from the nearest meteorological station. The location information like elevation, latitude, and longitude were also collected. All these data were incorporated in the software, CROPWAT, to estimate the potential evapotranspiration (ET_0). Crop data like plants/m^2, cob length, cob diameter, grains/cob, 1000- grain weight, and grain yields of each treatment were recorded.

The crop was irrigated as per the design of the treatments. Measured quantity of water was applied ensuring drainage. Soil moisture was measured before each irrigation. The part of rainfall collected as drainage and the change in stored soil moisture during the period under consideration were subtracted from the applied water to obtain crop evapotranspiration (ET_c) i.e., the crop evapotranspiration for the specified period was,

$ET_{ct} = W_a - (D_w \pm \Delta S_s)$

Where, ET_{ct} = crop evapotranspiration in mm for time, t

W_a = applied water + rainfall, mm, for time, t

D_w= drainage water, mm, for time, t

ΔS_s= stored soil moisture, mm, for time, t

Then from the potential evapotranspiration (ET_0) estimated for the specified period, the value of K_c for the period was determined from the ratio, FT_c / ET_0. The yield was adjusted for 14% moisture content using the following equation (Roy *et al.*, 1994),

Y_1 = y (100-m) /(100-M)

Where,

Y_1 = grain yield at the desired moisture percent

y = sample grain weight

m = sample moisture content, %

M = desired moisture content of grains, %

Results and Discussion

From Table 1, it appears that treatment T_1 received irrigation more frequently allowing less aeration facilities at the root zone resulting in lower yield of maize. It took 5-7 days to complete the drainage from the tanks. Thus, there were only 3-5 days left for this treatment to receive irrigation water again. So, the soil moisture situations in this treatment did not allow plants get favourable growing conditions throughout the season. On the other hand, treatment T_2, irrigated at 15 days interval, got 8-10 days time to receive the next irrigation. This interval seems much more favourable for plant growth, but treatment T_3 seems to be the best. Watering at 25 days interval (T_4) seems too long to provide adequate moisture to plants for normal growth. There might have some sort of water stress in the tank that affected crop. The treatment T_3, with irrigation interval of 20 days, produced the highest yield, kernels/cob, cob-diameter, and cob-length. This treatment got 13-15 days to bring soil moisture from the waterlogged situation to a suitable field condition for the crop. This indicates that the irrigation interval set for this treatment provided the most favourable environment for plants to produce the highest yield. Thus, this treatment was selected for determining the crop co-efficient values of the crop.

Table 1. Yield and yield parameters of BARI Hybrid Maize.

Treatments	Plants/ tank	Cob length (cm)	Cob dia. (cm)	Cobs/ plant	1000-grain wt (g)	Yield (t/ha)
T_1	8	19.00	4.30	1.00	359	8.80
T_2	8	18.66	4.47	1.25	450	10.62
T_3	8	19.33	4.58	1.50	484	11.78
T_4	8	18.33	4.37	1.50	405	10.28

In this study, 4 different intervals, 10, 15, 20, and 25 days were used for irrigating the treatment plots. Out of them, the treatment with 20 days irrigation interval (T_3) performed the best in respect of growth and yield. The optimum crop co-efficients at different growth stages are recommended to calculate from the best growing plants producing the highest yields (Doorenbos and Pruitt, 1977). It is expected that such conditions apply only to crops grown under optimum soil moisture and associated environments. So, all the calculations for the determination of K_c were based on the performance of treatment T_3 and are presented in Table 2.

Table 2, Determination of crop evapotranspiration used by the treatment T_3.

Duration (days)	Applied water (mm)	Effective rainfall (mm)	Percolation (mm)	Change in soil water storage (mm)	Crop ET (mm)
0-25	3	0.00	0.00	-17.96	20.96
26-45	60	0.00	21.55	-7.02	45.47
46-65	55	0.00	13.35	-16.65	58.30
66-85	60	4.80	4.16	-28.50	89.00
86-105	100	26.27	1.20	38.97	44.02
105-135	95	65.60	18.67	55.35	86.58

For germination of seeds, it took 5 days. So, the first duration in column I of Table 2 becomes 0-25 days. Further, the last irrigation was applied at 105 days after sowing and the crop was harvested at 135 DAS making the duration 105-135. The negative sign in column 5 of Table 2 indicates that the plants depleted water from the initial soil moisture content. On the other hand, the positive sign indicates that more water was stored in soil in excess of initial water content. Using Table 2, a curve was constructed with cumulative crop ET against days after sowing (Fig. 2).

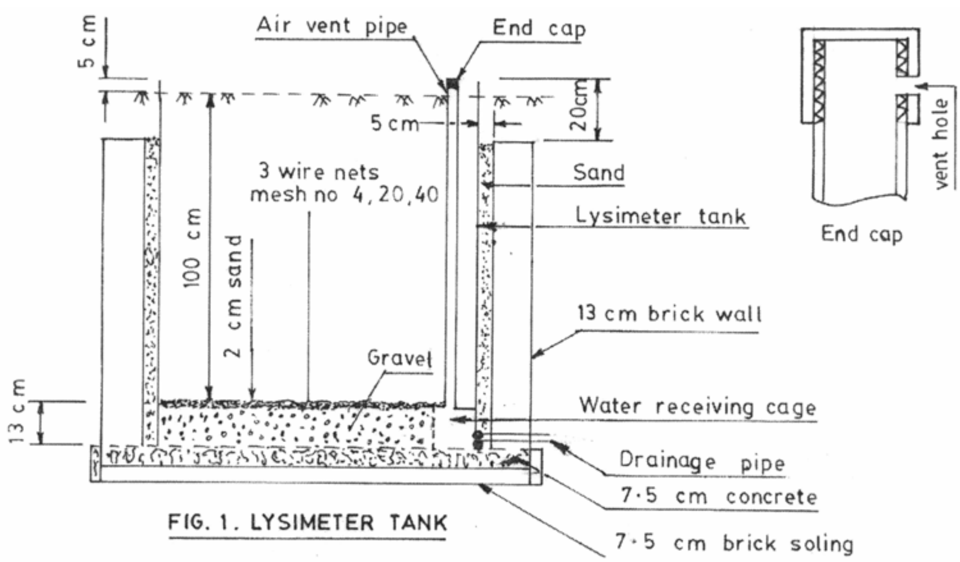

FIG. 1. LYSIMETER TANK

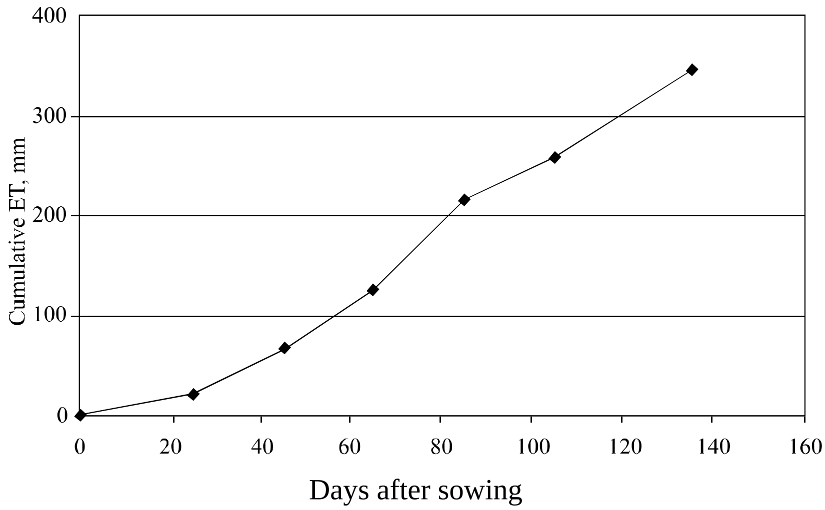

Fig. 2. Relationship between cumulative ET and days after sowing

The internationally recognized crop growth stages for the calculation of crop coefficients to estimate crop ET are initial, development, midseason and late season stages. The duration of each stage depends on the length of growing season of a particular crop and climate (Smithy, 1992; Doorenbos and Pruitt, 1977). Considering the crop, local climate and length of growing season of the crop, the following stages and durations were used in this study.

Initial stage 20 days

Development stage 40 days

Mid-season stage 50 days

Late-season stage 25 days

The values of crop ET for these development stages were obtained from the graph of Fig.2. The ET_0 was estimated from the climatic data as mentioned earlier. Thus, having crop ET and ET_o, the values of crop co-efficients for different stages of BARI Hybrid Maize-I were calculated (Table 3). Since the graph was constructed using Table 2 and the values of crop ET for initial (20 days), development (40 days), mid-season (50 days) and late-season (25 days) stages were obtained from the graph, the durations of Table 2 and 3 were different.

Table 3. Calculations of crop co-efficients for BARI Hybrid Maize-I.

Development Stage	Duration (Days)	Crop ET (mm)	ET_0 (mm)	Crop Co-efficient
Initial	20 (0-20 DAS)*	18	48.15	0.38
Development	40 (21-60 DAS)	87	100.00	0.87
Mid season	50 (61-110 DAS)	145	106.6	1.36
Late season	25 (111-135 DAS)	86.6	116.38	0.75

* DAS days after sowing

The crop co-efficient values, determined by this experiment, were found to vary to some extent from those recommended by FAO (Doorenbos and Pruitt, 1977). The FAO values are, 0.4, 0.80, 1.15, and 0.70 for initial, development, mid season, and late season stages, respectively. FAO values are the generalized ones recommended for use worldwide but those determined by this study are location specific. Another reason for this variation of K_c values might be the use of specific variety of hybrid maize in this experiment. However, locally determined K_c values are preferable to generalized standard values to estimate location specific crop evapotranspiration.

Conclusions

The crop coefficient values of BARI Hybrid Maize-I at initial, development, mid season and late season stages were found to be 0.38, 0.87, 1.36, and 0.75, respectively, from the lysimeter study. These values differed from the standard values to some extent (Doorenbos and Pruitt, 1977). Since, these K_c values were determined matching the local conditions of soil, plant, and environment, they are more accurate than the standard ones. Thus, to estimate the crop water requirement of BARI Hybrid Maize-I, the values determined under this study are recommended for use in Bangladesh.

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