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Crop Coefficient and Water Requirement of Tomato (*Melka Shola* Variety) at Melkassa, Central Rift Valley of Ethiopia

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Improved water management through precise crop water requirement determination is needed to improve water productivity in agricultural production. As a result, appropriate irrigation scheduling which can lead to water saving, improvements in the yield and income can be designed. In this study, non-weighing type lysimeters were used to determine water requirement (ETc) and crop coefficient (Kc) of Tomato (*Melka Shola* cultivar). Reference crop evapotranspiration (ETo) was determined using weather data of the site computing with modified Penman Monteith method. The measured average stage-wise ETc values were 43.53 mm, 112.50 mm, 270.63 mm, and 124.98 mm during the initial, development, mid-season and late season growth stages, respectively. The average crop coefficient (Kc) values, calculated as ratio of Etc to ETo, were 0.57, 0.86, 1.13 and 0.88 for the initial stage, developmental stage, mid-season stage and of late season stages, respectively. The crop coefficient value at the end of the late season stages was found to be 0.63.The length of each of the growth stages of initial, development, mid-season and late-season were 14, 25, 36 and 29 days, respectively. The water requirement and crop coefficient values determined in this study will help to accurately plan and manage the water resources in production of tomato.

Keywords: crop coefficient, crop water requirement, evapotranspiration, lysimeter, tomato

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INTRODUCTION

Tomato is one of economically important and widely grown vegetable crop under both rainfed and irrigation condition in Ethiopia (MoA, 2013; AVRDC, 2014).According to (CSA, 2012/13), Ethiopia devoted 7,257.45 ha to produce393,730.22 tons of tomatoes. Recently due to expansion of state farms and private investment which are basically concentrated in the rift valley areas of Ethiopia, commercial production of tomato has been increasing under irrigation agriculture.As the production of the crop increases knowing the exact amount of water required for the crop is the priority to manage the scarce water resources in the area.

Knowledge of crop-water requirements is crucial for water resources management and planning in order to improve water-use efficiency (Katerji and Rana, 2008). Decisions related to agricultural water management such as irrigation scheduling, water resources allocation and planning require the information about the water required for a given crop. Water loss from a given cropped plot of land can be determined from the knowledge of reference evapotranspiration (ETo), potential evapotranspiration (ETc), and crop coefficient (Kc).This loss is a function of crop characteristics, environmental aspects and management practices (Allen *et al*., 1998).

Crop coefficient represents crop specific water use and is essential for accurate estimation of irrigation requirement of different crops in the command area. It serves as an aggregation of the physical and physiological differences between crops and the reference definition. The variation of the crop coefficient during a growing season can be obtained experimentally (Burman *et al*., 1980; Doorenbos and Pruitt, 1977; Jensen, 1974; Pruitt *et al*., 1987).The crop coefficient is dependent upon stage of cropgrowth, canopy height, cover and architecture (Allen*et al*., 1998).

Although there are published Kc values for different crops, these values are commonly used in places where local data are not available. As these values vary from place to place and from season toseason, there is a strong need for local calibration of crop coefficients under given climatic conditions (Tyagi*et al*., 2000). There is, therefore, a pressing need to experimentally measure crop coefficients locally, so that irrigation water users can use more accurate water amount.

As the water requirement data and crop coefficient of the study crop is not locally available, knowledge of experimentally determined Kc value is important for proper irrigation scheduling and efficient water management of the selected crop variety. Therefore, this study was undertaken with the objective of developing crop coefficient for different growth stages of Tomato (*MelkaShola*).

MATERIALS AND METHODS

Description of the study area and experimental lysimeters

The study was conducted at Melkassa Agricultural Research Center for four consecutive years (2010 to 2013) in the cool season, starting from mid of October. The center is located inthe Central Rift Valley of Ethiopia at 8°24′N latitude, 39°21′E longitude, and altitude of1,550 m above sea level. The average annual rainfall is 818 mm and the mean maximum and minimum temperatures are 28.7°C and 13.8°C, respectively. Loam and clay loam soil textures are the dominant soils of the area.

The experiment was conducted on two non-weighing lysimeters of area 2 m x 2 m and 2 m x 1 meach year. The reference evapotranspiration (ETo) was calculated from daily climatic data collected from the meteorological station of the research centerlocated near the experimental lysimeters.

Crop Agronomy

Melka Shola tomato variety was used for the field experiment; it is a multipurpose variety released from Melkassa Agricultural Research Center. Tomato seeds were sown in a nursery in a row with the row spacing of 10 cm with dense spacing within rows. The size of the seedbed was 5 m length and 1 m width. The seed was drilled onto the seedbeds and covered with a soil layer of 1.5 cm. 100 g Urea and 200 g DAP were applied per bed and thoroughly mixed with the soil. Watering was done in the interval of two days throughout the growth period of the seedlings in the nursery. Transplanting was done on both the central lysimeter area and the buffer zone of 6 m x 6 m with row spacing of 90 cm and plant spacing of 30 cm.

Soil Moisture Measurement and Irrigation Application

Soil moisture content was regularly monitored for experimental plots before and after irrigation. Thus, calibrated neutron probe and gravimetrical method were used to determine the moisture content for each 15 cm soil layer up to105 cm maximum root depth. The soil moisture for the upper 0-15 cm depth was determined using gravimetric method, and neutron probe was used for the depths below the top layer based on the root depth considered. Theamount of irrigation water applied was based on the moisture content in the respective root zone andwas used to determine the crop evapotranspiration. The depleted soil moisture depth was refilled to the field capacity with graduated buckets.

Determination of Crop Evapotranspiration

The tomato crop evapotranspiration (ETc) was calculated using water balanceequation as follows:

$$ETc = I + R - D - \Delta S \qquad \text{equation 1}$$

Where: ETc= Evapotranspiration of the crop (mm), I = Irrigation water applied (mm), R_{eff} = Effective rainfall (mm), D = Drainage water collected (mm), and ΔS = Change in soil moisture storage (mm).

The inflows were rainfall and irrigation; the out flows were drainage and ETc. Daily amount of rainfall was obtained from theweather station located near the experimental plots and converted to effective rainfall using USDA soil conservation service method embedded in Cropwat model version 8.0. Deep percolated water

Table 1. Average potential crop evapotranspiration, reference crop evapotranspiration and crop coefficient values

Tomato (*Melka Shola)*	Growth Stage			
	Initial	**Developmental**	**Mid**	**Maturity**
Reference evapotranspiration ETo (mm/day)	5.64	5.22	5.07	5.10
Crop evapotranspiration ETc (mm/day)	3.23	4.50	5.73	4.46
Crop coefficient (Kc)	0.57	0.86	1.13	0.88

was measured with the help of graduated cylinder in the drainage collection chamber.

Determination of Reference Crop Evapotranspiration

The daily ETo data were calculated with Cropwat model version 8.0 on basis of FAOPenman-Monteith method (Allen *et al*., 1998). Daily metrological data such as minimum and maximum temperatures, sunshine hours, wind speed and average relative humidity were collected from Melkassa Agricultural Research Center's weather station.

Crop Coefficient

Crop coefficient was calculated by dividing the measured crop evaptranspiration (ETc) with the calculated reference evapotranspiration (ETo) from equation 2.

ETc = Kc x ETo equation 2

Where ETc = Crop evapotranspiraiton (mm), ETo = Reference crop evapotranspiration(mm), and Kc= crop coefficient.

RESULTS AND DISCUSSION

Crop evapotranspiration (ETc), reference evapotranspiration (ETo) and crop coefficient (Kc) for the four growth stages are presented in Table 1. The growth stage was represented by 14 days for the initial, 25 days for the development, 36days for mid and 29 days for the late growing stages totalizing 104 days after transplanting, which is within a range indicated by Doorenbos and Kassam (1979).

As indicated in the Table 1 the observed average daily Etc was low at the initial stage, increased during the development stage, reached maximum value of 5.73mm at mid-season stage and slightly declinedduring late-season stage. The difference in Etc is attributed to the combined effects ofphonological development of crop, changes in evaporative demand of the atmosphere and difference inenergy-absorption characteristics. The increase in Etc during the mid-season stage could beexplained by high evaporative demand and rapid fruit setting process.

The result showed that there is a general trend of Kc, i.e constant in initial stage, increment from end of initial stage to end of development stage, almost constant values in the midseason stage and decreasing in the late stage. The obtained Kc values were slightly higher than the values recommended by Doorenbos and Kassam (1979) for the growth period up to mid of developmental stage andit is within the range for the mid-and late season stages (Figure 1).

The stage-wise Etc of tomato varied from 3.07 to 3.36 mm $day^{-1}$for the initial stage, 4.06 to 4.86 mm $day^{-1}$for the development stage, 5.44 to 6.01 mm $day^{-1}$for the mid-season stage and 4.20 to 4.68 mm $day^{-1}$for the late-season stage. The stage-wise values of ETcof tomato indicate that there was a general increase in crop evapotranspiration from the initial to mid-season stage and decrease from the mid-season stage to harvest. The variations in ETc of the crop during the growing period could be related to the changes in crop canopy and climatic conditions.

The values of ETo varied from 5.39 to 5.94mm day^{-1}during the initial stage, 4.88 to 5.52mm day^{-1} for the development stage, 4.84 to 5.33mm day^{-1}during the mid-season stage, and 4.75 to 5.40mm day^{-1} during the late-season stage.

The stage-wise Kcof tomato varied from 0.55 to 0.60 for initial stage, 0.83 to 0.89 for development stage, 1.09 to 1.17 for mid-seasonstage, and 0.87 to 0.90 for the late season stage. The stage-wise values of Kcof tomato indicate that there was a general increase in Kcfrom the initial to mid-season stage and general decrease from the mid-season stage to harvest.

Figure 2 (a-d) shows the Kc values obtained in each year, from 2010/11 to 2013/14, as compared to the Kc values given by Doorenbos and Kassam (1979) in FAO-33. As it can be observed from the figures there were slight variations among the values across years, these might be due to variation in time interval between wetting events, the evaporation power of the atmosphere (ETo), the magnitude of the wetting event and climatic conditions (Savva and Frenken, 2002).

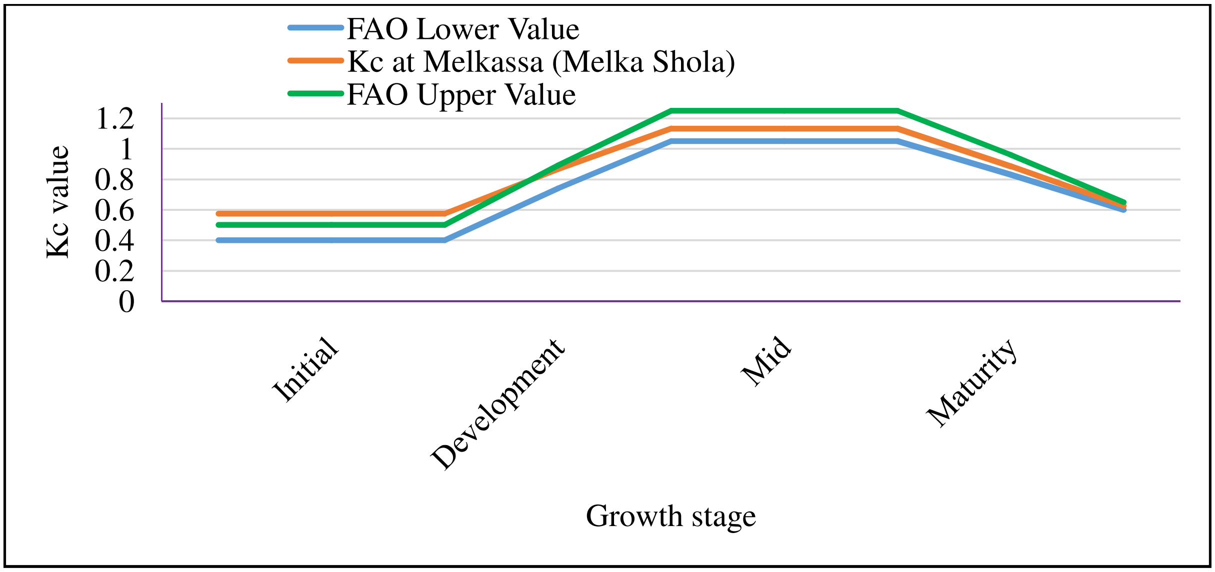

Figure 1. Average crop coefficient curves of tomato at Melkassa

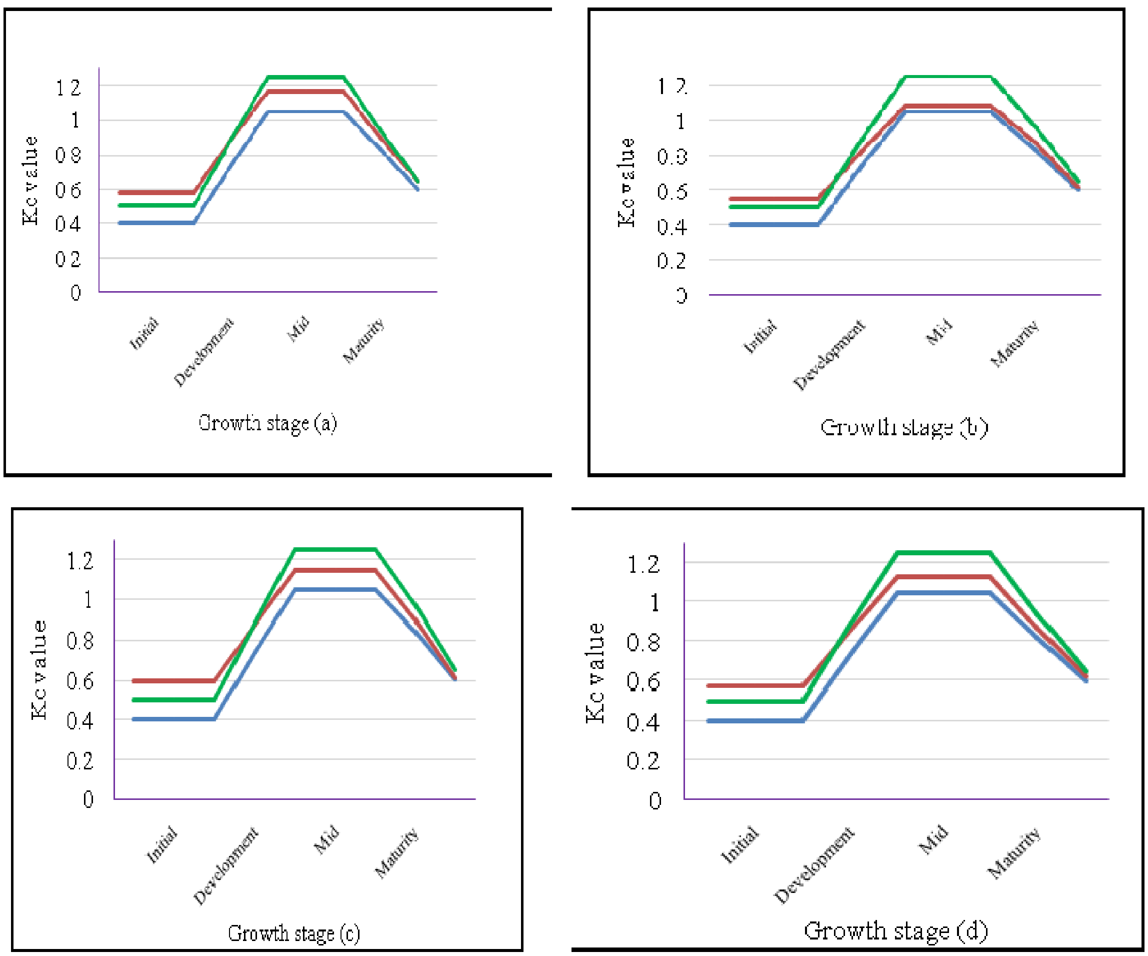

Figure 2. Crop coefficient Vs Growth stage curve of tomato at Melkassa as compared to FAO values. *a (2010/11), b(2011/12), c(2012/13) and d(2013/14) experimental year result

CONCLUSION

The average crop evapotranspiration (ETc) of *Melka Shola* tomato cultivar obtained at Melkassawere43.53 mm, 112.50 mm,207.63 mm, and 124.98 mm during the initial, development, mid-season and late season stages, respectively. The Kc values during initial, mid-season, and end of late season stages were0.57, 1.13and 0.63, respectively. Although the general trend is the same, the estimated values of Kcfor tomato (*Melka Shola* cultivar) at Melkassa were slightly different from those values in literature indicating the need for generating these values at the locallevel. The water requirement and crop coefficient values determined in this study willhelp to accurately plan and manage tomato production under irrigation.

REFERENCES

Allen, R.G., Pereira, L.S., Raes, D. and Smith, M. (1998). Crop Evapotranspiration, Guidelines for Computing Crop Water Requirements, FAO Irrigation and Drainage Paper No. 56. FAO, Rome, Italy.

AVRDC (Asian Vegetable Research and Development Center).(2014). Scoping study on vegetables seed systems and Policy in Ethiopia, report.

Burman, R.D., Nixon, P.R., Wright, J.L. and Pruitt, W.O. (1980). Water requirements; in: Design and Operation of Farm Irrigation Systems. Jensen, M.E. (ed.). Transaction of American Society of Agricultural Engineers, St. Joseph, Mich. pp: 189–232.

CSA (Central Statistics Agency). (2013). Agricultural Sample Survey 2012/2013. Volume I. Report on Area and Production of Major Crops (Private Peasant Holdings, Meher Season). Statistical Bulletin 532, Addis Ababa.

Doorenbos, J. and Pruitt, W.O. (1977). Guidelines for predicting crop water requirements; FAO Irrigation and Drainage Paper No. 24. FAO, Rome, Italy.

Doorenbos, J. and Kassam, A.H. (1979). Yield response to water; FAO Irrigation and Drainage Paper No. 33. FAO, Rome, Italy.

Jensen, M.(Ed.). (1974). Consumptive use of water and irrigation requirements; Rep. Tech. Com. on Irrigation Water Requirements; Irrigation and Drainage Division, American Society of Civil Engineers. 227 pp.

Katerji, N. and Rana, G. (2008). Crop evapotranspiration measurement and estimation in the Mediterranean region. 241: 2.

MoA (Ministry of Agriculture). (2013). Crop Variety Register, Issue No. 16. Addis Ababa Ethiopia.

Pruitt, W.O., Fereres, E., Kaita, K. and Snyder, R.L. (1987). Reference evapotranspiration (ETo) for California; no. 1922 in Agr. Exp. Sta. Bull.; Univ. of California.

Tyagi, N.K., Sharma, D.K. and Luthra, S.K. (2000). Determination of evapotranspiration and crop coefficients of rice and sunflower with lysimeter; Agricultural Water Management.

Savva, A. P and Frenken, K. (2002). Crop Water Requirements and Irrigation Scheduling FAO- East Africa, Zimbabwe, Harare.