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Estimate the crop coefficients for calculating crop water requirements of banana under Gizera condition, Sudan

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ABSTRACT

In Sudan, banana (Musa spp.) is produced commercially in small scattered orchards along the Nile banks and in large plantations at Kassala. Banana cv. Grand Nain is a newly released cultivar with high yielding potential and less sensitivity to cold temperatures. Currently, Grand Nain is becoming a popular banana cultivar in Sudan, but the yields are low due to lack of proper water management and fertilization systems. This study was undertaken to estimate the crop coefficients (K_c) values for the different growth stages of banana under Gezira conditions. The study showed the calculated K_c values were found to be 0.5, 0.8 and 1.1 for $K_{c\ ini}$, $K_{c\ dev}$ and $K_{c\ mid}$ respectively, in the first year, but in the second year it was constant at value 1.2. The crop water requirement of the mother banana plant and first ratoon crops was 30336 m^3/ha from transplanting to harvest.

Keywords: *Crop water requirement, Reference evapotranspiration, crop coefficients, Grand Nain.*

INTRODUCTION

Banana fruits are popular in Sudan because they are cheap compared to other fruits (Bakhiet, 2006). Banana cv. Grand Nain is identified to be the major export variety worldwide and released to farmers in Sudan in 2001 (Bakheit and Ali, 2001). The plant of this cultivar is taller, higher in yield potential and lees sensitive to cool temperature than the local cultivar (Dawarf Cavendish). There is a high demand for export of this cultivar which will replace the widely grown banana cv. Dawarf Cavendish. Presently, Grand Nain is becoming a popular banana cultivar in Sudan, but the yields are low due to lack of proper water management practices.

In respect of water use, the banana plant has several important characteristics: A high evapotranspiration rate due to large broad leaves and large total leave area, a shallow, superficial root system compared with most tree fruit crops. a poor ability to withdraw water from a soil which is drying out and rapid physiological response to soil water deficit especially in conditions of high evaporation stress (Robinson and Villiers, 2007).

Banana has a high water demand a 25 mm rain per week is regarded as the minimum for satisfactory growth (Robinson, 1996). Water requirement of banana are met by effective rainfall and by irrigation. Stover and Simmonds (1987) reported a consumption of 900 to 1800 mm water during the growth and production cycle of banana plants grown in a tropical environment. Fathia, (1999) found the highest growth and yield of banana crop was obtained with water quantity of 2100 mm/season at intervals 5-7 days.

Crop coefficients

(K_c) used for estimating ET_c for specific crops by measuring potential or reference (ET_o) must be derived empirically for local crop based on local climatic conditions (Doorenbos and Pruitt, 1977). Allen, (1998) stated that the K_c for any period of the season can be derived by assuming that, during the initial and mid- season stage, K_c is constant and equal to the K_c value of the growth stage under consideration. During the crop development and late season stage, K_c varies linearly between the K_c at the end of the previous stage and the K_c at the beginning of the next stage, which is K_c end in the case of the late season stage (Allen, 1998). The following equation was used to compute the K_c value on each day of the entire season:

$$K_{ci} = K_{c\,prev} + \left[\frac{i - \sum(L_{prev}}{L_{stage}}\right](K_{c\,next} - K_{c\,prev}) \quad \text{..... (1)}$$

In which:-

i =day number within the growing season [1. length of the growing season], $K_{c\,i}$ =crop coefficient on day I, L_{stage} =length of the stage under consideration [days] and $\sum(L_{prev})$ =sum of the lengths of all previous stages [days].

Accordingly, this study attempts to estimate the crop coefficients (K_c) values for the different growth stages of banana under Gezira conditions and crop water requirements of banana.

MATERIALS AND METHODS

The experiment was established in the Horticultural Research Centre Farm of the Agricultural Research Corporation (ARC), Wad Medani, Sudan (latitude 14° 23´N, longitude 33° 29´ E, altitude 405 m above mean sea level). The climatic zone of the study area is dry and characterized by hot summers.

The crop water requirement

Crop water requirement was expressed in units of water volume per unit land area (m^3/ha), depth per unit time (mm/day) according to Jensen (1993). A crop water requirement was calculated according to Allen, (1998) using the following formula

$$ET_c = ET_0 \times Kc \text{..... (3)}$$

Where:-

ET_c = crop evapotranspiration [mm d^{-1}], K_c = crop coefficient [dimensionless] and ET_o = reference crop evapotranspiration [mm d^{-1}].

Reference evapotranspiration calculated

The daily metrological data (maximum and minimum air temperature, relative humidity, sunshine duration and wind speed at 2 meter height) from Wad Medani Metrological Station were recorded during the study period to compute the daily reference evapotranspiration (ET_o) by *REF-ET* software version 2.0 developed by Allen (2000).

Adjustment of FAO crop coefficient

The standard K_c for every growth stage (initial, mid and end) of banana was taken from FAO-56 documentation (Table 12), and adjusted to local field (Table 1). The K_c for the mid- growth stage of banana was adjusted to the local climatic conditions by using the climatological data (wind speed at 2 meter height and minimum relative humidity). The maximum mean height of banana plants was taken from the field weekly. The adjusted K_c values of the mid- growth stage of banana was computed according to Allen, (1998) as follows:

$$K_{c\,mid} = K_{c\,mid\,(Tab)} + [0.04(u_2 - 2) - 0.004(RH_{min} - 45)]\left(\frac{h}{3}\right)^{0.3} \quad \text{...(2)}$$

In which:-

$K_{c\ mid\ (Tab)}$ =value for K_c mid taken from Table 12, u_2 = mean value for daily wind speed at 2 m height over grass during the midseason growth stage [m s^{-1}], for 1 m $s^{-1} \leq$ u2 $\leq$ 6 m s^{-1}, RH_{min} = mean value for daily minimum relative humidity during the mid-season growth stage [%], for 20% $\leq RH_{min} \leq$ 80% and h = mean plant height during the mid-season stage [m] for 0.1 m < h < 10 m.

Table 1. FAO 56 banana crop coefficient

	$K_{c\ ini}$	$K_{c\ mid}$	$K_{c\ end}$
First year	0.50	1.10	1.00
Second year	1.00	1.20	1.10

Source: FAO-56 documentation table 12

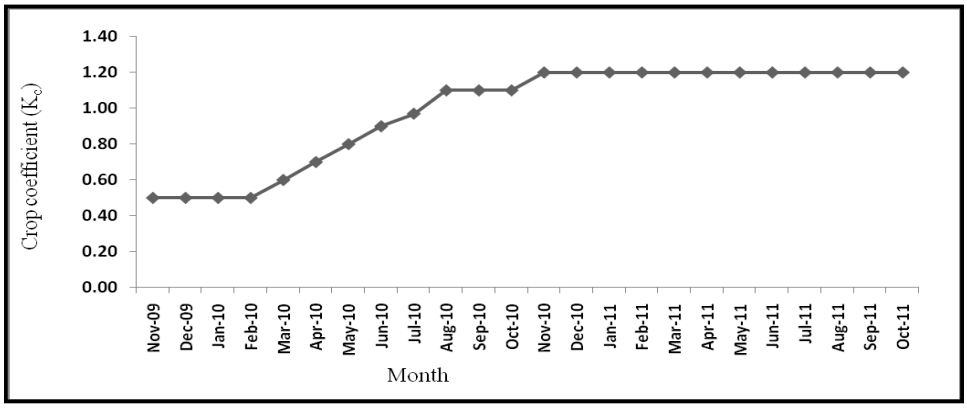
RESULTS AND DISCUSSION

Crop coefficient

The K_c values were computed for the two growth stages of banana the crop development stage and the mid- season stage. The mean values of K_c and stage duration (days) were presented in table 2. Figure (1) Showed that the K_c values of crop developmental stages increased linearly with time till it reached the mid- stage where the $K_{c\ mid}$ remained constant (represented by a horizontal straight line). The late season stage $K_{c\ end}$ runs from the start of maturity to harvest but banana was harvested at start of maturity. The K_c in the second year was constant at the value 1.2 because every three months two suckers were left and the ground cover is more than 60% which indicated that no initial stage at second year.

Table 2. The mean values of crop coefficient and stage duration days

Crop stage	Stage duration (days)	Calculated crop coefficient (K_c)
Initial (1st year)	105	0.5
Crop development (1st year)	140	0.8
Mid season (1st year)	120	1.1
Total (1st year)	365	-
2nd year	-	1.2



Figurre 1. Crop coefficient of the mother plant and the first ratoon crops of banana cv. Grand Nain

Reference evapotranspiration

Figure (2) showed the reference evapotranspiration from November 2009 to October 2011. The reference evapotranspiration increased from February and reached the maximum in May then it decreased in July to reach the minimum in August every year.

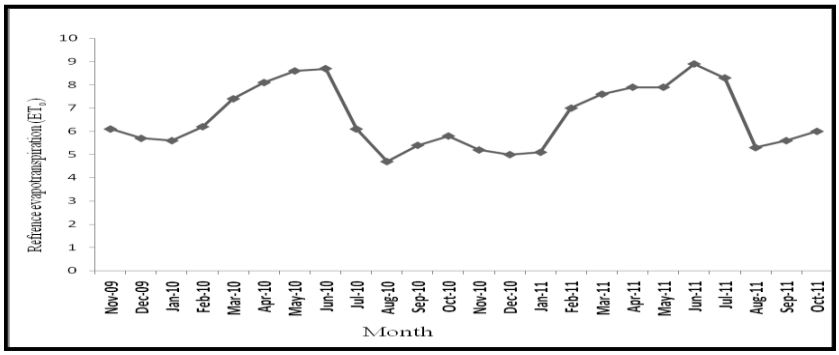


Figure 2. Reference evapotranspiration of the mother plant and first ratoon crops of banana cv. Grand Nain from November 2009 to October 2011

Crop evapotranspiration

The crop evapotranspiration (ET_c) is a term that describes the water consumed by a crop during the growing season. Figure 3 showed the average monthly crop evapotranspiration (mm/day) for the mother plant and the first ratoon crops of banana. The crop evapotranspiration started with low value (3.1 mm/day) during the initial stage and then increased to a peak (7.5 mm/day) in June. The consumption of water in the second year was greater (10.7 mm/day in June) than in the first year because the number of plants per pit were more than three. The average value of crop evapotranspiration of banana was 6.5 mm/day.

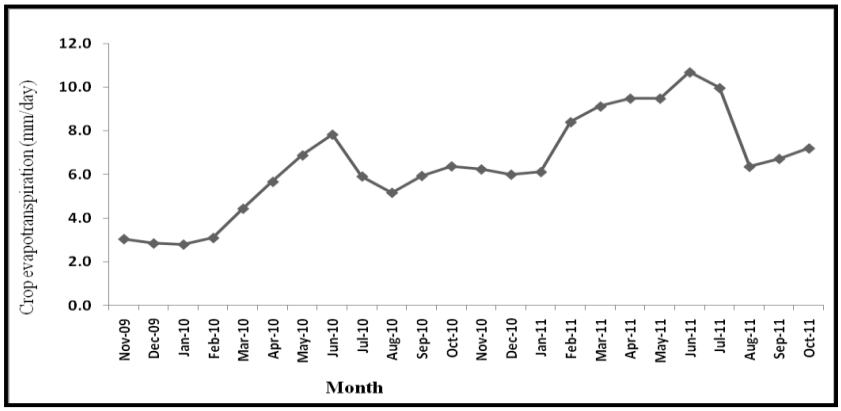


Figure 3. Crop evapotranspiration of the mother plant and first ratoon crops of banana cv. Grand Nain from November 2009 to October 2011

CONCLUSION

- Results of this study showed a variation of K_c values with different growth stages of banana. In the first year, the calculated K_c values were found to be 0.5, 0.8 and 1.1 for $K_{c\ ini}$, $K_{c\ dev}$ and $K_{c\ mid}$ respectively, but in the second year it was constant at value 1.2.
- The crop water requirement of the mother banana plant and first ratoon crops in the study area of Gezira was 30336 m^3/ha from transplanting to harvest.

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