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ESTIMATION OF WATER REQUIREMENT OF EARLY AND LATE SEASON TOMATO (*LYCOPERSICON ESCULENTUM MILL*) IN CALABAR, SOUTHEAST NIGERIA.

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ABSTRACT

The estimation of water requirements of early and late season tomato was conducted based on 10 years meteorological data at Calabar typical of the humid tropical zone, using the Penman's equation. Results showed that the seasonal crop evapotranspiration (ETo) value for early season tomato (March – July) was 60.8mm/day, while that of late season (September – December) was 73.6mm/day. The result showed that the water requirement for the late season was 2.0% higher than the early season tomato. However, water deficit tended to be greater in flowering than at yield formation. The calculated monthly crop coefficient (Kc/month) values for early season and late season tomato (the initial, crop development, and late season stages) were the same. The Kc values increased from low value at a time of crop emergence to a maximum value during the period when the crop reached full development, and declined thereafter when the crop matured. These results are discussed in light of estimation of water requirement of early and late season of tomato in Calabar.

KEY WORDS: Water Requirement, Tomato, Season.

INTRODUCTION

Tomato (*Lycopersicon esculentum*, mill) which is perhaps the most important crop in the world (Phene, 1989) and also an important constituent of the daily diet of most Nigerians is not grown commercially in Southern Nigeria. According to FAO (1980) estimates, Nigeria produces about 600,000 metric tones of tomato fruits annually, with the northern savanna zones as the main production centre.

The factors which limit large scale tomato production in the humid tropical lowlands of Nigeria can be traced to inadequate information on the production of the crop. Others include high relative humidity (51-87%), temperatures (20-33^{o}C) and high rainfall, averaging 2,162.7mm annually (NAPA) meteorological station Calabar (2006). The crop needs well drained and fertile soil with pH of 5.8-6.8. Tomato probably originated in the peru-Ecurdor region and is now grown in most climatic zones in Africa, tropical Asia, tropical America and the tropics. Cultivars grown include flattered, furrowed fruits, Burpees Best, marmande, marsol rounded fruits Ace, floridade, marglobe, Moneymaker, Moteya, Pearson, elongated fruits: Cambell 28, Heinz 1370, Petomech, Roma (Williams *et al* 1991). There are also numerous cultivars with firm-fleshed fruits of the florida type.

A single tomato plant can produce 2-5kg, depending on the environment, equivalent to 5-15 tones/ha (FAO 1984).

Water shortage during early flowering reduces the number of fruits and its deficit during yield formation period leads to small fruits and low yield (Raemaekers, 2001, Degras, 2005). In effect, more water supply to the crop and adequate nutrients are required at these growth stages. Ridge (1991) reported that water forms over 90% by weight of plant tissues hence, plant experiencing drought conditions are unable to grow efficiently. The implication is that the demand for water by crops must be met by water in the soil via the root system, and that the amount of water stored in the soil must be equal to the loss of water by evapotranspiration. The fact that tomato requires adequate amount of water means there is much need to determine the exact water requirements for both seasons as to reasonably know the best management option for greater economic returns to the farmer.

The objectives of the study were to determine crop water requirements and indicate the months with water deficit.

MATERIALS AND METHODS

The study was conducted at Calabar which lies within latitude 4^{o}37'N and 4^{o}41'N and longitude 8^{o} 9'E and 8^{o}12'E (White 1964). The humid forest zone of Nigeria. The annual rainfall in Calabar ranges from 1900mm to 2200mm, bimodally distributed with peaks in July and September. The soil is sandy clay loam (Course textured) and classified as an coastal plan soil. (Njoku *et al* 2001).

The study was based on 10 years (1997-2007) meteorological data collected from the Nigerian Airport Authority meteorological station, Calabar – Cross River State.

The meteorological data are presented in Table 1 and 2 and were used for the computation of the reference or potential crop evapotranspiration (ETo). Reference crop evapotranspiration (ETo) is defined as the rate of evaporation of an extended surface of 15-18cm tall green cover, actively growing, completely shading the ground and not short of water (FAO 1986). It therefore represents the climatic evaporation demand and tends to predict the effect of climate on crop. The

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reference crop evapotranspiration (ETo) was therefore calculated based on Penman's equation. This equation is one of the empirical formulae that uses climatic data such as temperature, relative humidity, total wind speed and actual sunshine duration to estimate crop water requirements (FAO 1986). The Penman's equation is stated thus:

$ETo = C [w \times Rn + (I-w) \times f(u) \times (ea - ed)$ …(1)

Where ea – ed = vapour pressure deficit (mbar)

F (u) = wind function (km/day)

W = temperature and altitude depended factor (T in ^oC, altitude in M)

C = adjustment factor for the ratio U (day/night)

Rn = total net radiation in mm/day

THE GROWTH PERIOD OF TOMATO

The growth period of tomato at first harvest varies from 90 to 150 days (Phene, 1989). The growth stages were separated into initial, crop development, mid season and late season stages of 30, 40, 40 and 25 days respectively (Adelana and Simons, 1980; Phene, 1989 and Quinn, 2000). The crop was assumed to have been sown within the recommended periods for the early and late season cultivation of tomato in the tropics (Thompson, 1996). The late season tomato was assumed to have been planted on the 20th of August and harvested on the 30th of November. The crop coefficients (KC) of 0.45, 0.75, 1.15 and 0.8 for initial crop development, mid season and late season growth stages of tomato respectively, were taken from FAO (1986).

The value of Kc varies with crop, development stage of the crop and to some extend with wind speed and humidity. For most crops, the Kc value increases from a low value at time of crop emergence to a maximum value during the period when the crop reaches full development, and then declines as the crop matures (FAO, 1986).

Crop evapotranspiration (ET_{crop}) refers to conditions when water is adequate for unrestricted growth and development.

Crop evapotranspiration (ET_m or ET_{crop}) water determined as: $ET_{crop} = ET_o \times Kc$… (2).

The Kc value at each of the growth stages was calculated to monthly Kc as

$$Kc/month = \frac{Kc\ growth\ stage \times N}{30} \quad …..\quad (3)$$

Where N = number of days growth lasted in a month and each month was assured to have 30 days

Monthly crop evapotranspiration (ET_{crop}/months) was obtained as a product of ET_o and Kc/month. Seasonal ET_{crop} values were calculated by summing the monthly values.

To calculate actual evapotranspiration for each of the growth stages, apply;

$$ET_a = \frac{S_a D}{t}\ 1 - \left((I - P)e - ETM \ \frac{t}{(1-p\ \ S_aD} + \frac{P}{1-p} \right)$$

ET_o is the actual evapotranspiration for the initial growth stage: 30 days parameters

ET_m = 4.4mm/day

Sa = 140mm

T = 30 days (initial stage)

P = 0.4

D = 0.7

Pe = 20mm/months

ET_a – 140 (0.7) (20 – (4.4) 30 + 0.4)

30 (1-0.4) 140 (0.7) 1.04

= 60.88mm/day

For crop development stage 40 days

T = 40 days

ET_a = 140 (0.7 [20 – (4.4) 40 + 0.4]

40 (1-0.4) 140 (0.7) 1-0.4)

= 2.45 [20 – 2.99 + 0.670

= 43.32mm/day

For late season stage 25 days

T = 25 days

ET_a = 140 (0.7) [20 – 4.4 (25) + 0.4]

25 (1-0.4) 140 (0.7) 1-0.4

= 3.92 [20 – 1.9 + 0.67]

= 73.6mm/day.

To calculate the total actual water requirement for same crop.

Water requirement ET_m = Kc, ET_o

ET_o = C (W.Rs) 2006 climate data

C = 0.98, W = 0.76; Rs = 2.13

ET_o = 0.98 [0.76 x 2.13]; Kc = 0.76 (Table

= 1.6mm/day

Water requirement ETm = 0.76 x 1.6

= 1.3mm/period.

To indicate the months with moisture deficit for tomato

Moisture deficit is greater in yield formation than vegetative stage i.e. flowering > yield formation > vegetative moisture deficit for the month.

Crop Dev. Stage > mid season stage

Mid season stage > late season stage

Late season stage > initial stage

RESULTS AND DISCUSSION

Table 1a shows the meteorological data of Calabar in which daily reference crop evaporation ET_o varied from 2.91 to 5.89 mm/day with a mean of 4.43 mm/day while the monthly ET_o varied from 98.73 to 163.42 mm/month with a mean of 127.6 mm/month (Table 1b). The ET_o values were higher in the drier months of January to April but lower in the wetter months of July and August. Similar results were reported by Chukwu (1999), Chukwu and Igbokwe (2001), Iren and Osodeke (2006).

The calculated monthly crop coefficient (Kc/month) values for the early season and late season tomato from the initial, crop development, mid and late season stages were the same (Table 2), and the reported trend is similar to earlier results (FAO, 1986; Messian, 1992) in which Kc values increased from a low value at time of crop emergence to a maximum value during the period when the crop reached full development and thereafter declined when the crop matured. The highest Kc values were recorded in the month of May and June (0.83 and 0.98) for early season and October and November (0.83 and 0.98) for the late season tomato. Interestingly, these months coincided with the productive and maturity stages of growth in tomato and are found to be the most active growth stage (FAO, 1986; Phene, 1989, Thompson, 1996; Quinn, 2000). The result also showed that the water requirement for the late season tomato was 2.0% high than the early season tomato. Indeed, the effective rainfall tended to be higher than the water requirement for tomato throughout the growth period of the early season, indicating that water deficit will not be a problem for the good performance of the crop earlier in the season (Cobley and Steele, 1976; Noggle and Fritz, 1992; Reameakers, 2001). The results justified the selection of Calabar, Cross River State, Nigeria as an ideal place for the cultivation of tomato, for greater economic returns to the farmer.

CONCLUSION

The implication of these findings is that Calabar area of Southeast Nigeria crop water requirement ET_{crop} for tomato would be higher during the late season than other periods. Water deficit is greater in yield formation later in the season than early in the season. The reproduction and maturity periods tended to be later in the season in which more rain was expected and higher moisture regime was attained.

Table 1a Meteorological Data of Calabar from 1997 to 2006

Months	Total Rainfall (mm)	Air Temp. (C)			Relative Humility			Mean Total wind speed/ day (km/hr)	Sunshine hours	Mean day wind speed (u day) (m/sec)	Mean night wind speed (u night)	U day
		Max	Min	Mean	Max	Min	Mean					
Jan.	49.4	36	21	28.5	67	42	54.5	84.53	5.8	18.14	5.36	4.88
Feb.	3.8	38	23	30.5	78	48	63.0	96.68	6.5	18.18	9.38	9.34
Mar.	47.6	35	24	29.5	89	79	84.0	112.51	6.2	21.06	12.15	2.85
April	152.4	34	25	29.5	90	73	81.5	124.22	5.3	18.17	10.11	3.66
May	425.2	32	24	28.0	94	76	85.0	118.15	4.1	20.36	13.52	2.52
Jun.	191.6	31	24	27.5	96	75	89.0	114.18	3.3	18.25	12.10	2.18
Jul.	256.4	29	24	26.5	95	84	90.5	121.25	2.8	19.43	10.48	2.03
Aug.	510.1	28	24	26.0	94	87	89.5	120.36	3.4	19.74	9.37	1.98
Sept.	518.9	30	23	26.5	95	84	89.5	119.48	3.7	18.05	8.92	2.93
Oct.	525.8	32	23	27.5	96	83	87.5	108.10	4.8	17.55	9.71	2.58
Nov.	32.4	33	23	28.0	94	81		98.19	6.5	16.32	8.24	2.96
Dec.	36.2	33	23	28.0	93	72	82.5	94.47	7.8	17.24	9.02	2.95
Total	2749.8	3911.0	281.0	333.0	1081.0	884.0	897.0	1309.41	60.2	218.49	118.36	40.46
Mean	229.15	32.58	23.4	28.0	90.08	73.7	74.8	109.12	5.0	18.20	9.86	3.37
Max = Maximum Mix = Minimum												

Table 1b Estimation of water requirement of early and late season tomato (*Lycopesicum esculentum)*

Months	**ET_o mm/day**	**ET_o mm/month**
Jan.	5.12	141.13
Feb.	5.71	138.17
Mar.	5.89	162.42
April	4.47	156.05
May	4.69	149.35
Jun.	4.53	114.71
Jul.	2.91	98.34
Aug.	3.87	98.73
Sept.	4.19	102.51
Oct.	3.97	119.01
Nov.	3.98	129.30
Dec.	3.92	121.14
Total	53.24	153
Mean	4.43	127.6
ET_o = Reference crop evapotranspiration.		

Table 2: Monthly crop coefficient (Kc/month) for the early season and late season tomato

Early season tomato

Months	ETo (mm/month	KC/month
March	159.18	0.08
April	137.43	0.72
May	118.86	0.83
June	99.74	0.98
July	95.32	0.67
LATE SEASON TOMATO		
August	89.17	0.08
September	98.10	0.72
October	110.45	0.83
November	121.63	0.98
December	118.87	0.67

ETo = Reference crop evaporation, Kc = crop coefficient.

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