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Seasonality and Climatic Period Effects on Cucumber Evapotranspiration and Irrigation Water Requirement

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ABSTRACT

Poor knowledge of water requirements limits irrigation water management to produce crops throughout the year. Crop evapotranspiration and irrigation water requirement of cucumber were investigated theoretically at National Horticultural Research Institute, Ibadan in southwestern Nigeria, using Blaney-Cridle equation. Seasonality comprised dry season (December to March) and wet season (May to August). Climatic period comprised 10 and 5 years average. The results indicated that crop evapotranspiration of cucumber did not differ between seasons and climatic periods. Mean seasonal crop evapotranspiration (ET) were 482.17 mm and 482.8 mm for dry and wet seasons, respectively. Mean seasonal irrigation water requirements was 369.36 mm in the dry season and zero in the wet season to enhance judicious use of water resources to produce cucumber throughout the year in South-Western Nigeria. Applying 370 mm of irrigation water seasonally is recommended for dry season cropping. Under rainfed cropping, supplementary irrigation is not necessary.

Key words: crop, evapotranspiration, cucumber, irrigation, water requirement

INTRODUCTION

The doctrine of intergenerational equity (Weiss, 1992) confers on us not only the right to use natural resources on trust to satisfy the present needs, but also the obligation to conserve these resources for the future generations. One approach to resource conservation is to quantify resource inputs for production to avoid wastage. Agriculture in southwest, Nigeria is not sustainable since it is rainfed and the rainfall patterns over the years have been changing (Odekunle and Eludoyin, 2008). The Evapotranspiration (ET) information helps in understanding farm water and soil management for improved water use or introduction of non-native vegetation. Crop evapotranspiration (ETc) is a principal factor of crop productivity in humid and subhumid tropics. In these regions, when soil water is available, ETc can reach or even exceed 10 mm day^{-1} under low atmospheric humidity and high wind velocity conditions (Fasinmirin and Olufayo, 2009). Information on ETc and crop coefficients (Kc) is useful for normal irrigation planning and management purposes, for the development of basic irrigation schedules, and for most hydrologic water balance studies (Suleiman *et al.,* 2007).

Cucumber (*Cucumis sativus* L.) is the fourth most important vegetable crop after tomato, cabbage and onion in Asia (Tatlioglu, 1993), the second most important vegetable crop after tomato in Western Europe (Phu, 1998). It is thought to be one of the oldest vegetables cultivated by man with historical records dating back 5000 years (Wehner and Guner, 2004). In tropical Africa, the place of the crop has not been ranked. The objective of this study was to estimate crop evapotranspiration of cucumber in both dry and wet seasons, using medium term climatic data.

MATERIALS AND METHODS

The study was based on climatological data (Table 1), collected from the National Horticultural Research Institute, Ibadan , Oyo State, Southwest Nigeria. Details of the type of climatological data collected are presented on Table 1. Seasons comprised dry season (December to March) and wet season (May to August). Planting and harvesting periods of the crop at both seasons are shown in Table 3.

Computations were based on a total growth period of 120 days for cucumber (Allen, 1993). This was aggregated into 20, 35, 40 and 25 days, respectively with their corresponding crop coefficients of 0.45, 0.74, 0.9 and 0.75 for initial, crop development, mid-season and late season stages of growth (Table 2), (Chukwu, 1995). The ET crop was estimated with the formula of Blaney-Criddle (1950) as described by Brouwer and Heibloem (1986) (eqn.1).

The crop evapotranspiration (ET crop) of cucumber was estimated using:

ET crop = $ET_o Kc$; ……. (1)

where ET_o is the reference crop evapotranspiration and K_c is the mean crop coefficient at stage of growth as they were given by Allen *et al* (1996). Calculation of mean daily reference crop evapotranspiration (ET_o) was done using Blaney-Criddle (eqn.2) from 10 years (i.e 2000-2010) agrometeorological data.

$ET_o = p^* (0.46^*T_{mean} + 8)$…….(2)

Where: ET_o is the reference evapotranspiration [mm day^{-1}] (monthly)

T_{mean} is the mean daily temperature [°C] given as $T_{mean} = (T_{max} + T_{min})/2$

p is the mean daily percentage of annual daytime hours.

The effective rainfall was calculated with the method of USDA (Soil Conservation Service) (1970)(eqns 3 and 4) as $P_e = P_{tot} (125\text{-}0.2 P_{tot})/125$ for P_{tot}<250mm…….(3)

$P_e = 125+0.1P_{tot}$ for P_{tot}>250mm…….(4)

Where P_e is the effective rainfall and P_{tot} is the total monthly rainfall.

RESULTS

Table 4 shows monthly crop coefficient of cucumber at NIHORT, Ibadan. Monthly Kc for dry season was highest in February (0.9) followed by March (0.75), then January (0.74) while the lowest value was observed in December. Wet season followed a similar pattern with May having the lowest coefficient value of 0.45, followed by the month of June (0.71), and the month of August (0.75) while the month of July recorded the highest crop coefficient value of (0.9). The Kc month^{-1} rose steadily from the first months of planting (December and May), attained maximum values at the third months (February and July) and declined afterwards.

The mean crop evapotranspiration (ET crop) due to seasons is as shown in Table 5. Monthly Crop Evapotranspiration for dry season was highest in February (156.64mm) followed by March (132.18mm), then January (119.55mm) while the lowest value was observed in December (73.8mm).

Table 1: Mean monthly climatic data for a 10 year period (2000-2010) at NIHORT, Ibadan.

Month of the year	Total Rainfall	Max air Temp (°C)	Min air Temp (°C)	Relative humidity (%)	No of rain days	Soil temp (0-5cm)	W/speed (km/day)
Jan	19.35	34.4	20.9	76	2	28.1	48.3
Feb	36.50	35.9	22.7	78	2	29.6	64.5
Mar	62.05	35.8	24	83	6	31.1	65.4
Apr	145.92	33.7	23.5	84	8	30.3	64.8
May	179.74	32.4	22.9	84	11	29.6	56.9
June	225.30	30.8	22.6	86	16	28.1	55.7
July	190.87	29.5	22.5	89	17	27.1	59.9
Aug	136.62	28.7	22.2	89	16	26.4	63.7
Sept	263.16	30.2	22.2	89	19	27.3	53.9
Oct	187.67	31.6	22.8	87	14	28.0	43.8
Nov	32.75	33.4	22.8	85	3	28.7	39.5
Dec	3.19	34.8	21.8	82	1	28.6	43.5

Table 2: Crop stages of development

Stage	**Indicators**
Initial	This is the period from sowing or transplanting until the crop covers about 10% of the ground.
Crop development	This period starts at the end of the initial stage and lasts until the full ground cover has been reached (ground cover 70-80%); it does not necessarily mean that the crop is at its maximum height.
Mid season	This period starts at the end of the crop development stage and lasts until maturity; it includes flowering and grain-setting.
Late Season	This period starts at the end of the mid season stage and lasts until the last day of the harvest; it includes ripening.

Table 3: Planting date and growth stages of cucumber in each season.

Crop stage	Dry season	Wet season
Planting date	01-Dec	01-May
Initial stage, 20 days	1Dec -20 Dec	1May -20May
Crop development, 35 days	21 Dec-24 Jan.	21 May-24June
Mid season, 40 days	25Jan-5 March	25 June-5August
Late season, 25 days	6 -30 March	6-30 August
Last day of harvest	30-Mar	30-Aug

All months are assumed to be 30days

Table 4: Monthly crop coefficients of cucumber as affected by seasonality

Months	Dry season Kc values	Months	Wet season Kc values
December	0.45	May	0.45
January	0.74	June	0.71
February	0.9	July	0.9
Marc h	0.75	August	0.75

Table 5: Mean crop Evapotranspiration (ET_{crop}) of cucumber determined from 10-years (2000-2010) climatic data.

Months	Dry season ET_{crop} (mm)	Months	Wet season ET_{crop} (mm)
December	73.8	May	78.29
January	119.55	June	125.23
February	156.64	July	156.12
March	132.18	August	124.16
Seasonal ET_{crop}	484.17		482.8

Table 6: Effective rainfall (Pe) and Irrigation Water Requirements (IWR) of cucumber in the dry season due to climatic periods

Months	Climatic Periods			
	10 years Average		5 years Average	
	Pe (mm)	IWR (mm)	Pe (mm)	IWR (mm)
December	3.17	70.6	0.8	73.5
January	18.76	100.8	18.08	101.34
February	34.36	122.27	33.47	122.1
March	55.88	76.29	38.08	94.6
Total	112.17	369.36	90.04	391.54

Wet season followed a similar pattern with May having the lowest ETcrop value of 78.29 mm, which was followed by the months of August and June with ETcrop value of(124.16mm and 125.25mm), respectively while the highest ETcrop value was recorded in the month of July (156.12). The total ET crops due to seasonality were 482.17 and 483.8 mm for dry and wet seasons respectively. Irrespective of season, monthly ET crop followed the same trend.

Table 6 present the result for effective rainfall and irrigation water requirements of cucumber in the dry season due to climatic period. Irrigation water requirements were zero in the wet season but 369.36 mm and 391.54 mm, respectively in the dry season for 10 years and 5 years average climatic periods. It is evident from the Table 6 that the irrigation water requirements of cucumber in dry season ranged from 70.6-73.5 mm for initial stage (December) followed 100.8 mm-101.34 mm

for crop development stage (January) then 122.27mm - 122.10 mm for mid-season stage (February), while in the late season stage cucumber will require between 76.29 mm- 94.60 mm of irrigation water.

DISCUSSION

Crop growth lasted longest in February and July, which fell within the mid-season stages for dry and wet seasons, respectively. This stage is characterized by maximum vegetative cover, optimum photosynthetic activity and the translocation of photosynthesis into the sink (Dupriez and Leener, 1992). All these metabolic processes require a lot of water. At the mid-season stage transpiration losses of water are therefore expected to be at its peak. This explained the highest Kc month $^{-1}$ recorded in February and July for dry and wet seasons, respectively. The reported seasonal ET crop of 484.17 mm and 482.8 mm for dry and wet seasons respectively are similar to the one reported by Chukwu (1995) and a range of 400.0 mm - 675.0 mm reported by Dupriez and Leener (1992). Effective rainfall was higher than ET crop from May through August but less than ET crop from December through February. This explained none requirement of irrigation in the wet season while supplementary irrigation is necessary during dry season.

CONCLUSION

The ET crop of cucumber did not vary widely in the dry and wet seasons irrespective of climatic periods in Ibadan, southwestern Nigeria. It varies from 484mm in the dry season to 482mm in the wet season. Applying 370 mm of irrigation water seasonally is recommended for dry season cropping. Under rainfed cropping, supplementary irrigation is not necessary.

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