Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 4, No. 3, p. 246-257, 2014
http://www.innspub.net

RESEARCH PAPER | OPEN ACCESS

Water requirements of some selected crops in Tono irrigation area

S. Adams[1*], G. W. Quansah[1], R. N. Issaka[2], E. A. Asamoah[3], K. A. Nketia[3], R. Amfo-otu[4]

[1]*Soil Chemistry and Mineralogy Division, CSIR-Soil Research Institute, PMB, Kumasi, Ghana*

[2]*Soil Fertility Division, CSIR-Soil Research Institute, Ghana*

[3]*Soil Genesis, Survey and Evaluation Division, CSIR-Soil Research Institute, PMB, Kumasi, Ghana*

[4]*Environmental and Natural Resources Management, Presbyterian University College, Akuapem Campus, Ghana*

Article published on March 22, 2014

Key words:

Abstract

The study was carried out to estimate the crop water requirement of some selected crops and determine whether the reservoir capacity is sufficient to irrigate the entire area of Tono irrigation site. Crops were planted during the 2008 dry season and the crop coefficient for each was determined. The study reveals that reference crop evapotranspiration (ETo) varied from a minimum of 4.43mm/day in July to the highest of 6.47mm/day in April. Crop evapotranspiration (ETc) and crop water requirement (CWR) for paddy rice varied from 0.57 to 6.84mm/day and 0.0 to 26.78mm/day, for tomato crop evapotranspiration and crop water requirement ranged from 3.22 and 7.01mm/day and 2.16 to 7.00mm/day, for soya bean crop evapotranspiration and crop water requirement varied from 2.15 to 6.52mm/day and 2.15 to 6.45mm/day, for maize crop evapotranspiration and crop water requirement varied from 1.61 to 6.88mm/day and 1.00 to 6.88mm/day, for pepper crop evapotranspiration and crop water requirement varied from 3.22 to 6.22mm/day and 1.9 to 6.22mm/day and for groundnut crop evapotranspiration and crop water requirement varied from 2.15 to 6.77mm/day and 2.15 to 6.77 respectively. The peak water requirement was 5.79mm/day or 0.67I/s/ha and the irrigation water requirement was estimated around 61MCM. With the capacity of 442MCM the dam can conveniently supply water to irrigate the area.

***Corresponding Author:** S. Adams ✉ sadick26589@itc.nl

Introduction

Agriculture is an essential driving force in the management of water use. Water serves different purposes such as agriculture purpose, domestic and industrial use and environmental use to sustain aquatic and terrestrial ecosystems. There is a great competition between municipal, industry users and agriculture for the finite amount of available water (Michael, 1999). Estimating irrigation water requirements accurately is important for water project planning and management (Michael, 1999). The main objective of irrigation is to apply water to maintain crop evapotranspiration (ET_c) when rainfall is insufficient. Broner and Schneekloth (2003) reported that water requirements of crops depend mainly on environmental conditions. Plant use water for cooling purposes and the driving force of this process is the prevailing weather conditions.

In Ghana, there are few irrigation projects to support farming activities for improved food production to ensure food security. There are many areas with great potentials to benefit from dams to enhance agricultural activities in the country. This has not been the case currently, and those that exist, not much studies have been conducted on the water usage and it implication on soil fertility and agricultural production. Tono dam is the largest reservoir in the Upper East Region of Ghana that provides water for irrigation of various crops.

Therefore this study was to determine crop water requirements of paddy rice, tomato, soya bean, maize, pepper and groundnut.

Materials and methods

Location and climate

The project lies in the guinea savannah ecological zone of Ghana and is located in the Upper East Region and lying between latitude 10 ° 45'N and longitude 1° W. It has a potential area of about 3840ha with a developed area of about 3450ha. The project area comprises eight (8) command areas, namely Bonia, Gaani, Korania, Wuru, Yigania, Yigwania, and Chuchuliga zone A and B.

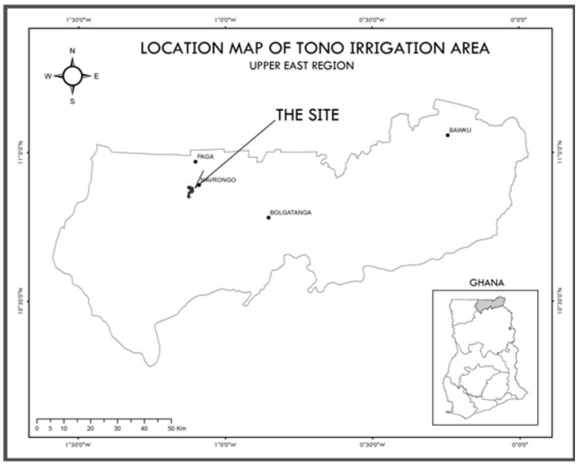

Fig. 1. Map of Ghana showing the location of Tono Irrigation Area (Adams *et. al.*).

The total annual rainfall in the area is around 950mm which normally begins in May, reach a peak in August then drop sharply in October. Thereafter, there is a long dry period from November to the end of April during which period only negligible amounts of rain are received.

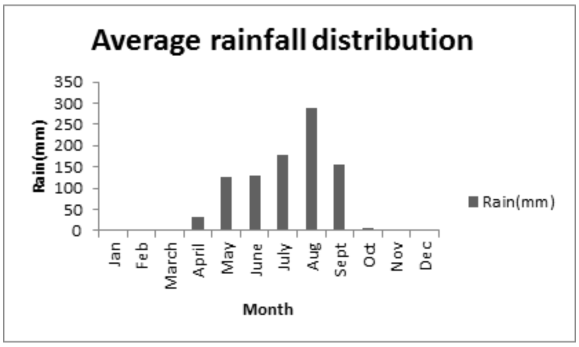

Fig. 2. Average rainfall distribution of Tono Irrigation Area.

Mean monthly temperatures remain high throughout the year only falling around 26° C in August and September at Navrongo. March and April are the hottest months recording nearly 32°C. Absolute minimum temperatures of around 16° c are usually recorded in December or January with absolute maximum temperature of about 35°C recorded in March and April.

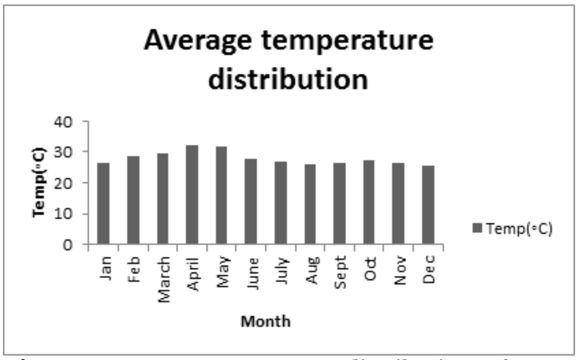

Fig. 3. Average temperature distribution of Tono Irrigation Area.

Relative humidity percent for the study area is high during rainy season in particular, from July to September, and low in the dry harmattan period from January to February. Detailed data indicate low diurnal and monthly humidity readings between noon and 1500 hours and high diurnal humidity readings between midnight and 0600 hours. Usually, humidity during the noon to 1500 hours period may be 20 to 30 percent lower than at 0900 hours.

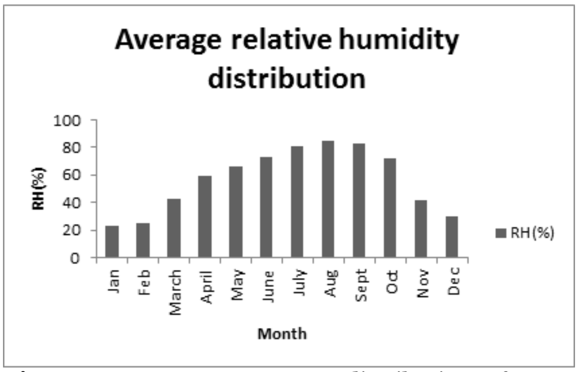

Fig. 4. Average temperature distribution of Tono Irrigation Area.

It has a potential area of about 3840ha with a developed area of about 3450ha. The source of water in the dam is from the river Tono and rain fed.

The irrigation system is based on gravity flow (Furrow irrigation), but the surrounding villages also extract water from the reservoir using pumping machine for domestic purpose. The top of dam embankment and wave wall are 182.57m and 183.20m. The gross storage capacity of the reservoir is 7574ha-metre and the dead water capacity 2097ha-metre. The system has a maximum emergency discharge capacity of 8.4m^3/s. The spillway level is 179.22m and beyond this level the water spillover. The spillover is normally observed between August and September.

Picture 1. Showing Tono reservoir.

The canal system is divided into three: main canal, lateral and sub-lateral. The main canal consists of right and left bank canals which have lengths of approximately 8.83km and 12.15km. The lateral and sub-lateral have length of approximately 44.8km and 42.2km. During the field visit, it was revealed that most of the laterals leading to the farm lands were broken down and large volumes of water were wasted.

Picture 2. Showing broken laterals.

The main canal which stretches from the reservoir to all the command areas had been rehabilitated.

Picture 3. Showing the rehabilitated main canal.

Relief and drainage

The survey area falls within the elevation range 154-170m above sea level. The topography is generally nearly level (0-2%) to gently sloping (2-5%). Steeper slopes of between 5-9% occur occasionally on isolated hills and inselbergs.

Owing to the generally low relief, surface runoff is slow but along the gentle slopes runoff has caused moderate to slight erosion. A number of extensive depressions are seen throughout the area. These become waterlogged or flooded during wet seasons but become dry in the alternate dry season (SRI, 2009).

Vegetation and land use

The original tree-savannah vegetation of the area has been largely destroyed by farming activities most of the trees being felled for firewood and building construction.

Batyrespernum parkii (shea butter tree) is the dominant economic tree species, while Teak, an exotic plant, occurs scattered throughout the area. Other existing trees include *Diospyrus mespillferais, Perkia filicoidia* (dawadawa tree), *Adansonia digitata* (baobah tree), *Anogeissus leocarpus, Vitex cionkowskii, Entanda abyssinica, Sterculia tomontosa, Bombax buonopozense, Balanites aegyptinca* and Ficus species of the grasses, *Aristidakerstingii, Heteropogoncontotus* and *Eragrestis* species are dominant and occur in association with few medium and tall grasses including *Penisetuapediselatum, Rotboeliaoxaltata* and *Hyparrheniarufa* (SRI, 1999).

Farming is normally carried on around settlements but in dry seasons, a few vegetable gardens can be found mainly along the alluvial flats of the Tono River and some of its tributaries.

Soil classification

The system of soil classification was developed by the staff of the survey department of the Soil Research Institute, Ghana. The classification system was derived from the FAO/UNESCO legend (1988). The soil units mapped were of a higher category (association) with a scale of 1:250000. Field traversing operation was used to produce the soil map. The classification was based on soil properties and diagnostic observation in the field at a wider range. The soil of the Tono command area is classified into two main groups: these are soils of the uplands and soils of valley bottom. The soils of the uplands are upper and middle slopes soils and are generally well drained. These comprise chuchuliga, Tanchera (Ferric Luvisol), kolingu (Ferric Luvisol), puga (Ferric Luvisol), wenchi (Lithosol), pusiga (Lithosol), gulo (Gleyic Luvisol), and pu series. The soils of valley bottom are confined to the valley of the valley of the Tono River and its tributaries. The soils of the valley bottom include kunkwa (Gleysol), Dagare (Eutric Flusol), siare (Chromic Vertisol), puni (Pellic Vertisol), sirru (Chromic Luvisol), Lapliki, Berenyasi (Eutric Gleysol) and kupela (Calcic Luvisol) series (SRI, 2009).

Estimation of water requirement

Climatic parameters that contribute to calculations of irrigation requirements are maximum and minimum temperatures, maximum and minimum air humidity, Sunshine hours, solar radiation and rainfall. These parameters have been found during a campaign of data collection in Tono and Navrongo weather stations.

FAO/UNESCO legend (1988) system was used to characterize soils types of Tono district. This was developed by the staff of the survey department of CSIR-Soil Research Institute, Ghana. The crops that are common in the study area and considered in this paper are paddy rice, tomato, soya bean, maize, pepper and groundnut.

The software that was used for computation was CROPWAT published and made available by FAO through the internet and the supporting document in the bulletin number 56. CROPWAT computes reference crop evapotranspiration, crop water requirement, irrigation water requirement, and irrigation scheduling and yield reduction due to water shortage of a given region, but this analysis was limited to reference crop evapotranspiration, crop water requirement, irrigation water requirement, net irrigation water requirement and scheme irrigation water requirement.

Three decades and seven distinct stages of plant growth were used in determining water requirement of the crop. The decades include the calculation period equal to 10 days while the crop growth stages include nursery, nursery/land preparation, land preparation, initial stage, development stage, and mid-season and late season stage.

Reference Evapotranspiration

Richard G. Allen *et al.* (1994) gave the methodology used for the calculations of irrigation water requirement, and developed in the FAO bulletin number 56 in 2002. The mentioned methodology begins with the calculation of Reference Evapotranspiration with the equation of Penmann Monteith as below:

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma\left(\frac{900}{T} + 273\right)u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.3u_2)}$$

1

Where

ET_o= Reference crop evaporation (mm/day)

R_n= Net radiation at the crop surface ($MJm^{-2}day^{-1}$)

G = Soil heat flux density ($MJm^{-2}day^{-1}$)

T = Mean daily air temperature at 2m height (°C)

u_2= Wind speed at 2m height (ms^{-1})

e_s= Saturated vapour pressure (kPa)

e_a= Actual vapour pressure (kPa)

Δ = Slope vapour pressure curve (kPa^oC^{-1})

e_s-e_a = Saturated vapour pressure deficit (kPa)

To ensure the integrity of computations, the weather measurements should be made at 2 m (or converted to that height) above an extensive surface of green grass, shading the ground and not short of water.

$$\gamma = \frac{C_p P}{\varepsilon\lambda} = 0.665 \times 10^{-3} P$$

2

Where

γ = Psychrometric constant (kPa^oC^{-1})

P = Atmospheric pressure (kPa)

Λ = Latent heat of vaporization, 2.45($MJKg^{-1}$)

Cp= Specific heat at constant pressure, 1.013×10^{-3}($MJKg^{-1}{}^oC^{-1}$)

ε= Ratio molecular weight of water vapour/dry air, 0.622

$$P = 101.3\left(\frac{293 - 0.0065Z}{293}\right)^{5.26}$$

3

Where

Z = Elevation above sea level (m)

As saturated vapour pressure is related to air temperature, it is calculated from air temperature. The relationship is given by

$$e^o(T) = 0.6108\exp\left(\frac{17.27T}{T + 237.3}\right)$$

4

Where

$e^o(T)$= Saturated vapour pressure at the air temperature T (kPa)

T = Air temperature

Due to the non-linearity of the above equation, the mean saturated vapour pressure for a day, week, decade or month should be computed as the mean between the saturated vapour pressure at the mean daily maximum and minimum air temperature for that period:

$$e_s = \frac{e^o(T_{max}) + e^o(T_{min})}{2}$$

5

For the calculation of evapotranspiration, the slope of the relationship between saturated vapour pressure and temperature is required. The slope of the curve at a given temperature is given by:

$$\Delta = \frac{4098\left[0.6108\exp\left(\frac{17.27T}{T+237.3}\right)\right]}{(T+237.3)^2}$$

6

The actual vapour pressure can be calculated from the relative humidity. Depending on the availability of the humidity data, different equations should be used:

$$e_a = \frac{\frac{e^o(T_{\min})RH_{\max}}{100} + \frac{e^o(T_{\max})RH_{\min}}{100}}{2}$$

7

Where

e_a = Actual vapour pressure (kPa)

$e^o(T_{\min})$ = Saturated vapour pressure at daily minimum temperature

$e^o(T_{\max})$ = Saturated vapour pressure at daily maximum temperature

$RH_{\min}$ = Minimum relative humidity (%)

$RH_{\max}$ = Maximum relative humidity (%)

In this study, Tono and Navrongo meteorological stations were selected for this purpose because it is situated in the irrigation command area. Once the ET_o value is calculated, the potential crop evapotranspiration is calculated by the product of ET_o and Crop coefficient (Kc):

$$ET_c = ET_o \times K_c$$

8

The weather measurements were taken at 2m above the surface of the green grass and the average climatic data were taken from 2001 to 2011. The major crops which are cultivated in Tono irrigation area are tomato, soya bean, pepper, groundnut and maize. These crops are mostly cultivated on the upland soils, and rice is predominantly grown on the valley bottom soils (lowland).

Results

Soil properties

Sixteen (16) soil series were identified in the study area, the soils in the area are predominantly coarse textured, ranging generally from sandy loam in the suface horizon to silt and clay in the subsurface horizon, with Wenchi series consisting of hard iron pan at the bottom(30+cm depth). FAO (1998) reported that sandy loam, loamy and sandy soils are relatively shallow and free-draining, particularly suitable for upland crops, and clay soils are deep but poorly drained and suitable for deep rooted crops like cotton. The soil pH generally ranges from 7.4 in the surface horizon to 5.8 in the subsurface horizon showing that the soil is predominantly acidic.The Cation Exchange Capacity was generally low from 0.87 to 15.1meq/100g, which means that the soils available have low potential for retaining plant nutrients.

Table 1. Reference Crop Evapotranspiration.

Country : Ghana — Meteorological Station: Tono

Coordinates: Lat. 10° 5'N Lon. 1°W — Altitude : 172m

Month	Max. T (° C)	Min. T (° C)	Humidity (%)	Wind (km/day)	Sunshine Hours	Radiation (MJ/m²/day)	ET_o (mm/day)
January	38.5	16.7	33	145	9.1	20.6	5.75
February	41.4	18.9	31	145	9.2	22.1	6.40
March	42.7	21.3	43	113	9.0	23.0	6.27
April	42.0	21.2	52	141	8.3	22.3	6.47
May	40.2	21.7	62	149	8.3	21.9	6.12
June	36.7	20.1	68	161	8.2	21.3	5.53
July	35.0	20.6	72	113	5.9	18.0	4.43
August	33.4	20.2	77	129	6.6	19.4	4.46
September	35.5	19.9	74	133	7.8	21.2	4.94
October	37.9	20.6	63	141	9.0	22.0	5.58
November	39.6	17.0	50	129	9.1	20.8	5.52
December	38.8	17.2	34	129	9.1	20.0	5.43
Year	**38.5**	**19.6**	**55**	**136**	**8.3**	**21.1**	**5.58**

ETo = Reference crop Evapotranspiration computed using FAO Penman-Monteith Method

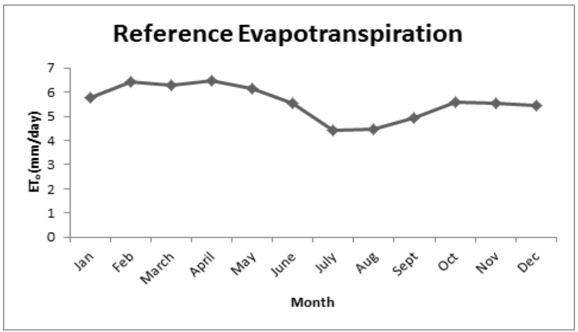

Fig. 5. Average reference evapotranspiration of Tono irrigation area.

Reference crop evapotranspiration

The results obtained when a 11-year period was used with the FAO-Penman Monteith method to estimate the reference crop evapotranspiration (ET_o) for the study area showed that ET_o varied from a minimum value of 4.43mm/day in July to the highest value of 6.47mm/day in April (Table 1). The results showed that ET_o was lowest during the peak of the rainy season to the highest during the peak of the dry season.

Table 2. Evapotranspiration and Irrigation Requirement for Paddy Rice.

Station: Tono			Date of transplant: 4 Nov. 2008					
Month	**Decade**	**Stage**	**Kc coeff**	**ETc mm/day**	**ETc mm/dec**	**Eff rain mm/dec**	**Irr. Req. mm/dec**	**Irr. Req mm/day**
Sep	1	N	1.2	0.57	4	32.4	0	0
Sep	2	N/L	1.11	3.86	38.6	44.7	117.6	11.76
Sep	3	N/L	1.06	5.49	54.9	31	267.8	26.78
Oct	1	Init	1.09	5.85	58.5	10.5	245.2	24.52
Oct	2	Init	1.1	6.14	61.4	0	61.4	6.14
Oct	3	Dev	1.11	6.2	68.2	0.2	67.9	6.17
Nov	1	Dev	1.16	6.43	64.3	1.6	62.6	6.26
Nov	2	Dev	1.21	6.65	66.5	0.7	65.8	6.58
Nov	3	Mid	1.23	6.77	67.7	0.5	67.3	6.73
Dec	1	Mid	1.23	6.74	67.4	0.1	67.3	6.73
Dec	2	Mid	1.23	6.71	67.1	0	67.1	6.71
Dec	3	Mid	1.23	6.84	75.2	0	75.2	6.84
Jan	1	Late	1.21	6.84	68.4	0	68.4	6.84
Jan	2	Late	1.16	6.7	67	0	67	6.70
Jan	3	Late	1.11	6.65	73.1	0.1	73	6.64
					902.3	122	1373.6	135.40

where N= Nursery, N/L= Nursery/Land preparation, Init= Initial stage, Development stage, Mid= Mid-Season stage, Late= Late season stage, IR= Irrigation Requirement (mm/day), IR= Irrigation Requirement (mm/dec), Kc= Crop Coefficient, ETc= Crop Evapotranspiration (mm/day), ETc= Crop Evapotranspiration (mm/dec).

Crop water requirement

The results showed that for paddy rice, crop evapotranspiration (ET_c) and crop water requirement varied from 0.57 to 6.84mm/day and 0.0 to 26.78mm/day respectively (Table 2). For tomato, crop evapotranspiration and crop water requirement ranged from 3.22 to 7.01mm/day and 2.16 to 7.00mm/day respectively (Table 3). For soya bean crop evapotranspiration and crop water requirement ranged from 2.15 to 6.52mm/day and 2.15 to 6.45mm/day respectively (Table 4). For maize crop evapotranspiration and crop water requirement ranged from 1.61 to 6.88mm/day and 1.00 to 6.88mm/day respectively (Table 5). For pepper crop evapotranspiration and crop water requirement ranged from 3.22 to 6.22mm/day and 1.9 to 6.22mm/day respectively (Table 6). Finally for groundnut crop evapotranspiration and crop water requirement ranged from 2.15 to 6.77mm/day and 2.15 to 6.77mm/day respectively (Table 7).

Table 3. Evapotranspiration and Irrigation Requirement for Tomato.

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/day	Irr. Req. mm/dec
Oct	1	Init	0.6	3.22	16.1	5.3	2.16	10.8
Oct	2	Init	0.6	3.35	33.5	0	3.35	33.5
Oct	3	Init	0.6	3.34	36.7	0.2	3.32	36.5
Nov	1	Deve	0.63	3.49	34.9	1.6	3.33	33.3
Nov	2	Deve	0.77	4.23	42.3	0.7	4.16	41.6
Nov	3	Deve	0.91	5.01	50.1	0.5	4.97	49.7
Dec	1	Deve	1.06	5.78	57.8	0.1	5.77	57.7
Dec	2	Mid	1.17	6.38	63.8	0	6.38	63.8
Dec	3	Mid	1.18	6.55	72	0	6.55	72
Jan	1	Mid	1.18	6.67	66.7	0	6.67	66.7
Jan	2	Mid	1.18	6.8	68	0	6.8	68
Jan	3	Late	1.18	7.01	77.2	0.1	7	77
Feb	1	Late	1.08	6.7	67	0.2	6.68	66.8
Feb	2	Late	0.97	6.2	62	0.3	6.17	61.7
Feb	3	Late	0.87	5.53	38.7	0.7	5.41	37.9
					786.8	9.7	78.72	777

Table 4. Evapotranspiration and Irrigation Requirement for Soyabean.

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/day	Irr. Req. mm/dec
Oct	1	Init	0.4	2.15	6.4	3.2	2.15	6.4
Oct	2	Init	0.4	2.23	22.3	0	2.23	22.3
Oct	3	Deve	0.61	3.41	37.5	0.2	3.39	37.3
Nov	1	Mid	1.1	6.11	61.1	1.6	5.94	59.4
Nov	2	Mid	1.18	6.52	65.2	0.7	6.45	64.5
Nov	3	Mid	1.18	6.48	64.8	0.5	6.44	64.4
Dec	1	Mid	1.18	6.45	64.5	0.1	6.43	64.3
Dec	2	Late	1.14	6.18	61.8	0	6.18	61.8
Dec	3	Late	0.75	4.13	45.5	0	4.14	45.5
					429.1	6.4	43.35	425.9

Table 5. Evapotranspiration and Irrigation Requirement for Maize.

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/day	Irr. Req. mm/dec
Oct	1	Init	0.3	1.61	11.3	7.4	1	6
Oct	2	Init	0.3	1.67	16.7	0	1.67	16.7
Oct	3	Deve	0.39	2.16	23.7	0.2	2.14	23.5
Nov	1	Deve	0.66	3.68	36.8	1.6	3.51	35.1
Nov	2	Deve	0.93	5.15	51.5	0.7	5.08	50.8
Nov	3	Mid	1.19	6.51	65.1	0.5	6.47	64.7
Dec	1	Mid	1.24	6.79	67.9	0.1	6.77	67.7
Dec	2	Mid	1.24	6.75	67.5	0	6.75	67.5
Dec	3	Mid	1.24	6.88	75.7	0	6.88	75.7
Jan	1	Late	1.21	6.85	68.5	0	6.85	68.5
Jan	2	Late	0.96	5.52	55.2	0	5.52	55.2
Jan	3	Late	0.65	3.86	42.5	0.1	3.86	42.4
Feb	1	Late	0.41	2.53	12.7	0.1	2.53	12.6
					595	10.8	59.03	586.3

Table 6. Evapotranspiration and Irrigation Requirement for Pepper.

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/day	Irr. Req. mm/dec
Oct	1	Init	0.6	3.22	12.9	4.2	1.9	7.6
Oct	2	Init	0.6	3.35	33.5	0	3.35	33.5
Oct	3	Init	0.6	3.34	36.7	0.2	3.32	36.5
Nov	1	Deve	0.62	3.44	34.4	1.6	3.27	32.7
Nov	2	Deve	0.74	4.11	41.1	0.7	4.04	40.4
Nov	3	Deve	0.88	4.85	48.5	0.5	4.8	48
Dec	1	Deve	1.02	5.57	55.7	0.1	5.56	55.6
Dec	2	Mid	1.08	5.88	58.8	0	5.88	58.8
Dec	3	Mid	1.08	6	66	0	6	66
Jan	1	Mid	1.08	6.11	61.1	0	6.11	61.1
Jan	2	Late	1.08	6.22	62.2	0	6.22	62.2
Jan	3	Late	1.03	6.15	67.7	0.1	6.15	67.6
Feb	1	Late	0.96	5.95	47.6	0.1	5.93	47.4
					626.2	7.7	62.53	617.4

Table 7. Evapotranspiration and Irrigation Requirement for Groundnut.

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/day	Irr. Req. mm/dec
Oct	1	Init	0.4	2.15	2.1	1.1	2.15	2.1
Oct	2	Init	0.4	2.23	22.3	0	2.23	22.3
Oct	3	Init	0.4	2.22	24.5	0.2	2.2	24.2
Nov	1	Deve	0.46	2.56	25.6	1.6	2.4	24
Nov	2	Deve	0.68	3.74	37.4	0.7	3.67	36.7
Nov	3	Deve	0.9	4.94	49.4	0.5	4.89	48.9
Dec	1	Mid	1.12	6.09	60.9	0.1	6.08	60.8
Dec	2	Mid	1.18	6.4	64	0	6.4	64
Dec	3	Mid	1.18	6.52	71.8	0	6.52	71.8
Jan	1	Mid	1.18	6.65	66.5	0	6.65	66.5
Jan	2	Mid	1.18	6.77	67.7	0	6.77	67.7
Jan	3	Late	1.09	6.49	71.4	0.1	6.49	71.3
Feb	1	Late	0.86	5.32	53.2	0.2	5.3	53
Feb	2	Late	0.69	4.39	26.3	0.2	4.39	26.2
					643.2	4.7	66.14	639.6

Table 8. Scheme Irrigation Requirements.

Crop	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Rice	6.2	0	0	0	0	0	0	365.5	237.1	193.7	201.5	198.1
Tomato	159.7	0	0	0	0	0	0	0	0	120	185.5	200.6
Soya bean	0	0	0	0	0	0	0	0	5.7	184.8	167.5	2.9
Maize	14.4	0	0	0	0	0	0	0	0	145.8	202.9	161.9
Pepper	49.1	0	0	0	0	0	0	0	0	116.6	173	181.2
Groundnut	205.5	79.2	0	0	0	0	0	0	0	48.7	109.6	196.5
NSIR1	1.6	0.1	0	0	0	0	0	5.4	3.6	5.1	6.3	5.8
NSIR2	49.2	4	0	0	0	0	0	168.1	109.4	156.6	188	180.2
NSIR3	0.18	0.02	0	0	0	0	0	0.63	0.42	0.58	0.73	0.67
IA	94	5	0	0	0	0	0	46	52	100	100	100
NWR	0.2	0.33	0	0	0	0	0	1.36	0.81	0.58	0.73	0.67

where NSIR1= Net Scheme Irrigation Requirement (mm/day), NSIR2= Net Scheme Irrigation Requirement (mm/month), NSIR3= Net Scheme Irrigation Requirement (l/s/hr), IA= % of total area that is actually irrigated, NWR= Net Water Requirement for Actual Irrigated Area (l/s/hr),

Scheme irrigation requirement

The actual irrigation requirement of Tono irrigation project was estimated (Table 8). The net irrigation water requirement was 855.5mm/year. This was estimated by summing the net scheme irrigation requirement (NSIR2) from January to December. By using an irrigation application efficiency of 48%, the gross water requirement of 1782mm/year would be 17820m³/ha/year. Hence the developed land area of 3450ha will require 61MCM. The reservoir capacity is 442MCM and this capacity can satisfactorily irrigate the entire command areas

Discussion

The results showed that crops with longer growing season, such as rice and tomato have higher reference and crop evapotranspiration that those with shorter growing season. Moreover, the values for ET_o and ET_c were significant in dry season than the rainy season. FAO (2005) reported that crops grown in the dry season require more water that those grown in the rainy season. The range of water requirement for lowland rice was significantly higher because the water requirement during the peak rainy season was very low while that of the peak dry season was very high. Jehanger *et al.*, (2004) reported that rice require more water than those of other crops.

Conclusion

The study shows that the reservoir can sufficiently supply the water required for irrigation in the command areas used at present and also in the entire land area. The results obtained from the study can be used as a guide by farmers for selecting the amount and frequency of irrigation water for the crops studied under consideration.

Efficient and effective canal management mechanisms in terms of canals and laterals calibration should be continued to prevent possible crop water stress. Irrigation engineers and management should pay attention to crop water requirements of the various crops at the command areas. Irrigation requirement should be monitored periodically to ensure higher productivity.

Reference

Broner I and Schneekloth J. 2003. Seasonal Water Needs and Opportunities for Limited Irrigation for Colorado Crops, Newsletter of the Extension Irrigation Services, Dept. of Civil Engineering, Colorado State University. No. 4.718 http:/www.google search/water requirement.

Food and Agriculture Organization (FAO). 1992. CROPWAT: A Computer Program for Irrigation Planning and Management, by M. Smith. FAO Irrigation and Drainage Paper No. 46. Rome.

Food and Agriculture Organization (FAO). 2002. Crop Evapotranspiration Guidelines for Computing Crop Water Requirements: Guidelines for Computing Crop Water Requirements (FAO Irrigation and Drainage Paper No.56.

Food and Agriculture Organization (FAO). 2005. Irrigation water requirements, In: Irrigation Potential in Africa: A Basin Approach, Chapter 5, FAO Corporate Document Repository, FAO, and Rome. http://www.fao.org/docrep/W 4347E /w4347e00.htm

Hess T. 2005. Crop Water Requirements, Water and Agriculture, Water for Agriculture, WCA infoNET, http:// silsoe.cranfield.ac.uk/iwe/dailyet.htm

Jehanger WA, Turral H and Masih I. 2004. Water Productivity of Rice Crop in Irrigated Areas. Proceedings of the 4th International Crop Science Congress, Brisbane, Australia (26 Sept – 1 Oct 2004) http:/www.cropscience.org.au

Luca E, Nagy Z and Berchez M. 2003. Water Requirements of the Main Field Crops in Transylvania. Journal of Central European Agriculture **3(2),** 98-102.

Michael AM. 1999. Irrigation Theory and Practice. Vikas Publishing House, New Delhi, India. 530-539.

Schwab GO, Fangmeier DD, Elliot WJ and Frevert RK. 1993. Soil and Water Conservation Engineering, 4th ed. John Wiley and Sons. Pg. 390-395.

Smith MA, Monteith R, Pereira JL, Pereira LA, Perner A and Segreen A. 1991. Report on the Expert Consultants on Procedures for Revision of FAO Guidelines for Prediction of Crop Water Requirements, FAO, Rome, Italy.

Smith MA. 1992. Senior Irrigation Management Officer Water Resources, Development and Management Service FAO, Viale delle Terme di Caracalla, 00100 Rome, Italy.

Soil Research Institute (SRI). 1999. A review of the classification of soils at Tono Irrigation area, Ghana, 18-20.