Water Needs Strategy of Major Plant Crops Cultivated in The Countries of Nile River Basin

I.H. Elsokkary;[1] and A. F. Abukila[2]

ABSTRACT

The Nile River basin is flowing from south to north over 35 degree of latitude and is extending from the humid region to the desert region. The territories of Burundi, DR Congo, Egypt, Eretria, Ethiopia, Kenya, Rwanda, South Soudan, Sudan, Tanzania, and Uganda are located within the Nile River basin. These countries have wide range of rainfall varying from mean values of 1000 mm/year in the countries of humid region to less than 20 mm/year in countries of semi- desert and desert regions. The mean volumes of water withdrawal, as percentage of renewable water are 5.0 for Burundi, 0.0 for DR Congo, 92.0 for Egypt, 5.0 for Eritrea, 2.0 for Ethiopia, 3.0 for Kenya, 1.0 for Rwanda, 56.0 for Sudan and 1.0 for Uganda.

The crop water needs can be supplied from rainfall or from irrigation or by a combination of both. The irrigation water need (IWN) can be obtained by the difference between crop evapotranspiration (ET_{crop}) and the effective rainfall (P_e). Accordingly, in this investigation, the"Blanery and Criddle" method for the determination of reference evapotranspiration (ET_o) and crop factor (Kc) is employed for the determination of IWN of sorghum (*Sorghum bicolor*) plant cultivated in the countries of Nile basin. The data obtained indicated, comparatively, that the highest IWN is required by sorghum cultivated in Egypt and Sudan (582 and 524 mm/TGP) and the lowest is required by DR Congo, Ethiopia, Uganda and south Sudan (230, 239, 240 and 180 mm/TGP, respectively). As a result of suitable renewable management in irrigation, the expected percentages of water which can be saved from Nile water are 41.9, 48.9, 47.8 and 62.5 for Burundi, DR Congo, Uganda, and S. Sudan, respectively, and can be therefore a supplementary water source for other countries like Egypt and Sudan.

Key Words: Nile River Basin, Irrigation Water Need, Effective rainfall

INTRODUCTION

Africa is considered one of the driest continents of the world, as well as Australia, with an exception of the Congo/Zaire river basin. As a result of the variations in geology, geomorphology and climate; the continent exhibits major geographical distribution differences in rainfall and natural surface freshwater. As a result, there are spatial and maldistribution of renewable water resources in the continent. Thus, droughts are frequent in most African countries, and each year more people are at risk due to drought and relatively poor development of water resources (Crisman, *et al*., 2003).

The continent has several major river basins which are characterized by irregular and reliable flow among the areas of these basins (Table 1). Of a great concern, and/among the world's continents; Africa has the largest percentage (62%) of its land in international river basin. Thus, problems arise from that most countries can get its water from either within its own borders, from outside its borders or from both (Hutchinson *et al*., 1995, and FAO, 1997). This makes that the management of most African river basins is not the responsibility of one country but it must be within and under cooperation and fair agreement among countries of the specific river basin (McNeeley, 1999, and Rosegrant *et al*., 2002).

1.1 Water scarcity

The heaviest rainfall, in Africa, occurs near the equator and may exceed 2000 mm/year and then it diminishes toward the north regions of the continent. Large areas, therefore, are suffering acute water shortage which mostly lies in the northern parts of the continent. It has been assumed that countries with less than 1700 m^3 freshwater per person per year are suffering periodic water shortage and countries with below 1000 m^3 per person per year will suffer chronic water scarcity (Rosegrant *et al*., 2002). According to UN projections, by 2025, a fairly sizable proportion of the population of some African countries will not have sufficient water to meet their basic needs (Alcamo *et al*., 2000).

Taking into account the "criticality ratio" or the ratio of water withdrawl to the renewable water, which is an indicator of water scarcity, it can be estimated that some African countries are subjected to "high water stress". According to Alcamo *et al*., (2000), the higher "criticality ratio" the more intensive the use of water of river basin and, occasionally, these high ratios are recorded by downstream users and, therefore, water usage at this condition can be impaired. It is also clear

[1]Department of Soil and Water Sciences, Faculty of Agricultural, El-Shatby, Alexandria University.Alexandria, Egypt,
E-mail address: elsokkary35@gmail.com
[2]National Water Research Center, Drainage Research institute, Egypt El-Qanater El-Khairiya post code:13621,
E-mail address: Alaafg@gmail.com
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that during low flow periods, the chance of absolute water shortages increases. This indicates that criticality ratios equal to or greater than 0.4 are considered "high water stress" and that equal or greater than 0.8 are considered "very high water stress" (Alcamo *et al*., 2000). According to these ratios, Egypt is considered a country of "very high water stress".

1.2 The water of Nile Basin

The Nile River, with a length of nearly 7000 km, is the largest river in Africa. The total area of Nile basin represents about 10.28% of the continent's area and spreads over ten countries (Table 1 and Fig. 1). The total area of Nile basin is 3112369 km^2, of which the land area suitable for surface irrigation is 920190 km^2 and the irrigation potential of Nile basin is 8000km^2. The irrigation potential as percent of the area of the suitable land is 8.69%. This percentage is extremely small as a result of the occurrence of high percentage of lands in the sub-Sahara zone: Sudan and Egypt.

The Nile river flows from south to north over 35 degrees of latitude (FAO, 1995a). It is fed by two main river systems: the White Nile with its sources on the Equatorial lake plateau (Burundi, Rwanda, Tanzania, Kenya, DR Congo and Uganda), and the Blue Nile with its sources in the Ethiopian highlands (FAO, 1995a and Nile Basin Initiative, 2002). These sources are located in humid regions, with an average annual rainfall of 1000mm. The arid region, of Nile basin, starts from Sudan, which can be divided into three rainfall zones: the extreme south of the country with annual rainfall varying from 1200 to 1500 mm, the fertile clay-plains with annual rainfall from 400 to 800 mm, and the desert zone at northern part where rainfall averages only 20 mm per year. Further north is Egypt with annual rainfall (precipitation) less than 20 mm (Table 2).

The area of a specific country within the Nile basin widely varied among countries, and the largest was for Egypt, Ethiopia and Sudan, and the lowest was for Burundi, DR Congo and Rwanda (Tables 3 and 4). There are also wide variations in the irrigation potential among the countries where the highest is belonging to Egypt and Sudan (Tables 3 and 4).

All the waters in Burundi and Rwanda and more than half in Uganda are produced internally, while most of the water resources of Sudan and Egypt originate outside their borders; about 77% of Sudan's water and 97% of Egypt's water (FAO, 1995a; McNeely, 1999 and Nile Basin Initiative, 2002).

There are wide variations in the area under irrigation of each country and the largest is that of Sudan and Egypt (Table 4). On the other hand, Burundi and DR Congo agricultural and crop production system are using non-irrigated lands for crop production. However, these two last countries have an arise plans for increasing their cultivated area.

Table 5 shows that the irrigation water requirements, of the country's Nile basin, are the highest for Egypt, Kenya and Sudan countries and the lowest for Burundi, DR Congo, Eritrea and Rwanda. The same trend can be found with respect to the water withdrawn for agriculture from Nile River whether as quantity or as percentage (Nile Basin Initiative, 2002).

1.3 Food production

There is a growing concern for food production in Africa and this is especially in the sub-Saharan regions which suffer shortage in the rainfall. Under such conditions, both rainfed and irrigated agriculture should be intensified. While there still exists considerable potential for the future expansion of irrigation, in these regions, the water is growing scarce and, therefore, the need for irrigation is becoming more urgent. In order to enable careful planning for the development of water resources for irrigation, knowledge and data about irrigation potential and rainfed agriculture should be considered clearly. It has been reported that in developing countries, rainfed crop yields (wheat for example) remain far below irrigated crop yields. Rainfed cereal yields averaged 1.5 metric tons per hectare in the developing countries which is half irrigated cereal yields of 3.3 metric tons per hectare in the same countries. This yield is also less than half of the 3.2 metric tons per hectare of rainfed cereal yields, produced on the average, in the developed countries (Rosegrant *et al*., 2002).

1.4 Crop Water Needs

The crop water needs can be supplied from rainfall or from irrigation or by a combination from both. If the rainfall is sufficient to cover the water needs of the crop, irrigation is not required and if there is no rainfall, all water that the crop need has to be supplied by irrigation. It is obvious that part of the rainfall cannot be used by the plant (not effective) and the remaining part is stored in the root zone and can be used by plant (effective rainfall). Factors including; climate, soil texture, soil structure and depth of root zone influence the magnitudes of non-effective and effective rainfall (Brouwer and Heibloem, 1986).

The irrigation water need of a certain crop is the difference between the crop water need and that part of the rainfall which can be used by the crop (the effective rainfall). The crop water needs depend on the climate, the crop type and the growth stage of the crop. The major climatic factors are sunshine, temperature, humidity and wind speed (FAO, 1984 and FAO, 1992a).

Table 1. The areas and annual rainfall of the river basins in Africa*

River basin	Area		Rainfall (mm/year)		
	Km^2	% of Africa	Minimum	Maximum	Mean
Senegal	483,181	1.6	55	2,100	550
Niger	2,273,946	7.51	0	2,845	690
Lake Chad	2,381,635	7.86	0	1,590	415
Nile	3,112,369	10.28	0	2,060	615
Rift Valley	637,593	2.1	90	2,210	650
Shebelli-Juba	810,427	2.68	205	1,795	435
Congo/Zaire	3,789,053	12.51	720	2,115	1,470
Zambezi	1,351,365	4.46	535	2,220	930
Okavango	323,192	1.07	355	1,320	680
Limpopo	401,864	1.33	290	1,040	530
Orange	896,368	2.96	35	1,040	325
South Interior	645,826	2.13	270	905	435
North Interior (Sahara)	5,804,463	19.16	0	700	40
Mediterranean Coast	679,525	2.26	5	895	235
North West Coast	670,621	2.21	0	680	145
West Coast	1,430,196	4.72	350	3,395	1,435
West Central Coast	704,774	2.33	775	2,830	1,785
South West Coast	516,200	1.7	10	1,600	940
South Atlantic Coast	365,485	1.21	0	555	190
Indian Ocean Coast	663,785	2.19	125	1,770	680
East Central Coast	1,026,252	3.39	275	2,305	960
North East Coast	725,702	2.4	0	725	165
Madagascar	587,040	1.94	400	3,000	1,700
Islands	9,346	0.03			
Total for Africa	30,290,208	100			

* Hutchinson et al. (1995) and FAO (1997)

Table 2. The annual rainfall (mm) in the countries of Nile basin*

Country	Minimum	Maximum	Mean
Burundi	895	1570	1110
DR Congo	875	1915	1245
Egypt	0	120	15
Eritrea	240	665	520
Ethiopia	205	2010	1125
Kenya	505	1790	1260
Rwanda	840	1935	1105
Sudan	0	1610	500
Tanzania	625	1630	1015
Uganda	395	2060	1140
For Nile basin	0	2060	615

* FAO (1997)

Table 3. The country area of Nile basin*

Country	Country area (Km^2)	Area within the Nile basin		As % of the country in the Nile basin
		(Km^2)	As % of the total area of the Nile basin	
Burundi	**27,834**	**13,260**	**0.43**	**47.64**
DR Congo	2,344,860	22,143	0.71	0.94
Egypt	1,001,450	326,751	10.50	32.63
Eritrea	121,890	24,921	0.80	20.45
Ethiopia	1,100,010	365,117	11.73	33.19
Kenya	580,370	46,229	1.49	7.97
Rwanda	26,340	19,876	0.64	75.46
Sudan	2,505,810	1,978,506	63.57	78.96
Tanzania	945,090	84,200	2.71	8.91
Uganda	235,880	231,366	7.43	98.09
For Nile basin		3,112,369	100.00	

* FAO (1997)

Table 4. Area under irrigation by country of Nile basin and as percentage of country basin and the irrigation potential of each country in the basin*

	Area under irrigation			Irrigation potential (Km^2)
	(Km^2)	As % of the country basin	As % of the total area of the country	
Burundi	0	0.00	0.00	800
DR Congo	0	0.00	0.00	100
Egypt	30,780	9.42	3.07	44,200
Eritrea	151.24	0.61	0.12	1,500
Ethiopia	231.6	0.06	0.02	22,200
Kenya	60	0.13	0.01	1,800
Rwanda	20	0.10	0.08	1,500
Sudan	19,352	0.98	0.77	27,500
Tanzania	100	0.12	0.01	300
Uganda	91.2	0.04	0.04	2,020

* Nile Basin Initiative (2002)

Table 5. Irrigation water use per country of Nile basin in the year 2000*

Country	Total renewable water resources (Km^3)	Irrigation water requirements (Km^3)	Water requirement (rate in %)	Water withdrawal for agriculture (Km^3)	Water withdrawal (as a % of renewable water resources)
Burundi	3.6	0.06	30%	0.19	5%
DR Congo	1283	0.03	30%	0.11	0%
Egypt	58.3	28.43	53%	53.85	92%
Eritrea	6.3	0.09	32%	0.29	5%
Ethiopia	110	0.56	22%	2.47	2%
Kenya	30.2	0.3	30%	1.01	3%
Rwanda	5.2	0.01	30%	0.03	1%
Sudan	64.5	14.43	40%	36.07	56%
Tanzania	91	0.56	30%	1.85	2%
Uganda	66	0.03	30%	0.12	0%

* Nile Basin Initiative (2002)

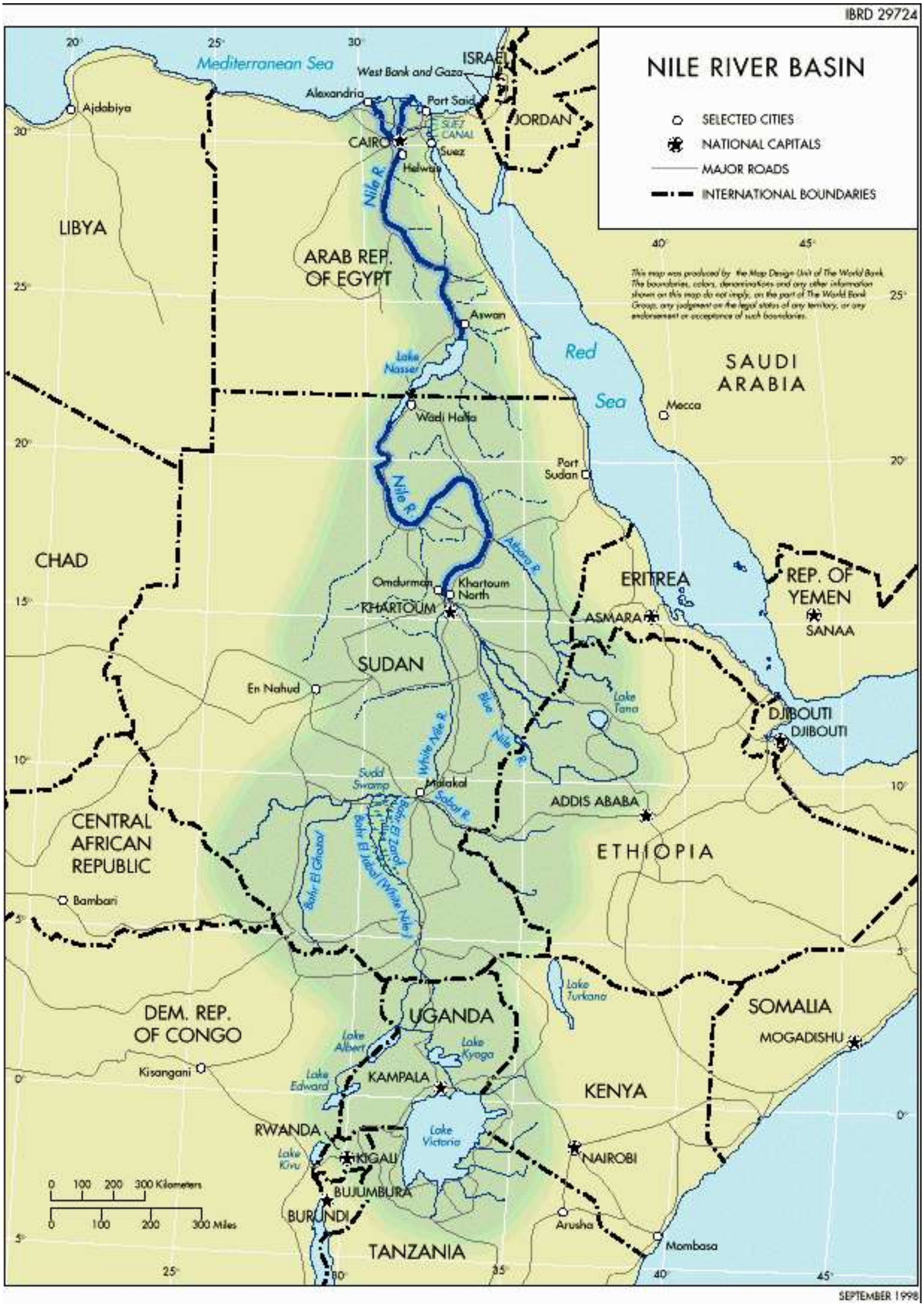

Fig. 1. The countries of Nile River basin

METHODS

1.5 Irrigation potential

In humid climate, where rainfall is more than 1200 mm/year, this amount is sufficient to cover the water needs of the various crops. In sub-humid and semi-arid climates, the rainfall range is between 400 and 1200 mm/year and this amount are important but not sufficient to cover the water needs of most crops. The crop production in dry season is only possible with irrigation, while the crop production in the rainy season may be possible but unreliable and yield will be less than optimal. In semi-arid and desert climate, the rainfall is less than 400 mm/year and reliable crop production based on rainfall is not possible and irrigation is thus required. This indicates that there are two factors which determine the amount of irrigation water: the total water needs of the crop and the amount of rainfall which is available.

The assessment of irrigation potential, based on soil and water resources can be carried out by assessing irrigation water requirement (IWR) and net irrigation water requirement (NIWR). Both depend upon cropping pattern and climatic conditions. The climate data can be obtained from the FAOCLIM cd-room (FAO, 1995b). These data set includes long term average of rainfall and reference potential evapotranspiration (ET_o) which is calculated by the Penman-Monteith method (FAO, 1992a). Moreover, the FAO's CROPWAT software can be used to compute the NIWR (FAO, 1992b).

The theoretic "Blaney-Criddle" method can be used to calculate the reference evapotranspiration (ET_o). This method is simple, using measured data on temperature and latitude (Table 6). However, the method is not very accurate. It provides a rough estimates or "order of magnitude" only as compared to Penman method which is rather complicated (FAO, 1984).

The "Blaney-Criddle" method always refers to the "mean monthly values", both for the temperature and the ET_0 The used formula is:

$ET_o = p\ (0.46\ T_{mean} + 8)$

Where:

ET_o: reference crop evapotranspiration (mm/day) as an average for a period of one month.

T_{mean}: mean daily temperature ($^{\circ}$C).

P: mean daily percentage of annual daytime hours.

To determine the values of "P" and mean temperature, the approximate latitude and mean temperature of the area are estimated (FAO, 1984; and Brouwer and Heibloem, 1986). The mean values of these two parameters are shown in Tables 6 and 7.

The crop water need (crop evapotranspiration: ET_{crop}) is obtained by the formula:

$ET_{crop} = ET_o \times Kc$

Where Kc is the crop factor (FAO, 1984).

Usually, ET_o and ET_{crop} are expressed in the same unit: mm/day (as an average for a period of one month) or in mm/month.

The crop factor (Kc) depends on both the type of the crop, growth stage of this crop and the climate.

The "Blaney-Criddle" method divides the growing period of a crop into four growth stages: initial, development, mid-season and late-season. The sum of these four growth stages is the "total growth period: TGP" in days. Also, for each crop, there are four Kc values which have to be determined (FAO, 1984).

Table 6. Estimated mean values of temperature and latitude of the countries of Nile basin*

Country	Temperature (^{o}C)			Latitude	
	Min.	Max.	Mean	Range	Mean
Burundi	17	23	20	03^0 00` S - $02^0$ 00` S	02^0 30` S
DR Congo	10	30	20	14^0 00` S - $06^0$ 00` N	08^0 00` N
Egypt	11	40	28	21^0 00` N - $31^0$ 00` N	26^0 00` N
Eritrea	18	32	25	12^0 00` N - $18^0$ 00` N	15^0 00` N
Ethiopia	8	25	16.5	03^0 00` N - $15^0$ 06` N	10^0 00` N
Kenya	12	28	20	05^0 00` S - $05^0$ 00` N	00^0 00`
Rwanda	23	28	25.5	02^0 30` S - $02^0$ 00` S	02^0 15` S
Sudan	17	43	29.5	11^0 00` N - $21^0$ 00` N	16^0 00` N
S. Sudan	22	30	26.5	03^0 00` N - $13^0$ 00` N	08^0 15` N
Tanzania	15	28	21.5	11^0 50` S - $01^0$ 00` S	06^0 30` S
Uganda	8	32	20	02^0 00` S - $04^0$ 00` N	03^0 00` N

* Brouwer and Heibloem (1986)

Table 7. The value of the mean daily percentage (P)*

Country	P
Burundi	0.270
DR Congo	0.280
Egypt	0.300
Eritrea	0.275
Ethiopia	0.280
Kenya	0.270
Rwanda	0.270
Sudan	0.280
S. Sudan	0.280
Tanzania	0.285
Uganda	0.270

* Brouwer and Heibloem (1986)

The water required by the plant can be supplied in various ways: by rainfall, by irrigation, or by a combination of both. In the case where all the water needed by the plant is provided by rainfall, irrigation is not required and the irrigation water need (IWN) equals zero (IWN = 0). In the case where there is no rainfall, the water has to be supplied by irrigation and hence, the IWN equals the ET_{crop}. In some cases, however, part of the ET_{crop} is supplied by rainfall and the remaining part by irrigation. In this case, the following formula is applied:

$IWN = ET_{crop} – P_e$

Where P_e is the effective rainfall (effective precipitation) in mm/month. The P_e value is obtained by the formula:

$P_e = 0.8 P-25$ if $P > 75$ mm/month

$P_e = 0.6 P-10$ if $P < 75$ mm/month

Where P is the precipitation or rainfall in mm/month.

RESULTS AND DISCUSSION

1.3 Irrigation Water Need for Sorghum

In the present investigation, sorghum (*Sorghum bicolor*) is used because it is a common cultivated crop in the countries of Nile basin for grains production and/or for fodder. It is relatively tolerant to salinity and is cultivated at wide range of geographical areas. This study represents “comparative data” about IWN of this crop when cultivated in the countries of Nile basin.

According to “Blanery and Criddle” method, there are five steps required for calculating the IWN of sorghum; the determination of ET_o, Kc, ET_{crop}, effective rainfall and then IWN. The mean values of ET_o and ET_{crop} are given in Table 8.

The values of Kc for sorghum at the initial growth stage, at development stage, mid-season stage and late stage are 0.35, 0.75, 1.15 and 0.65, respectively (FAO, 1984). The approximate duration of the four growth stage is 20, 30, 40 and 30 days, respectively with total growth period (TGP) of 120 days.

Table 9 showed wide variations in the values of ET_{crop} (mm/TGP) as a result of geographical and consequently climatic conditions. The highest values are those of sorghum cultivated in Egypt, Sudan and Eritrea. At certain conditions, the water demand of the crop is potentially increasing according to climatic conditions but the water supply from the rainfall may decline or may not full satisfy the demand. According to Table 9, it is clear that IWN of sorghum, cultivated in the countries of Nile basin, is influence by climatic conditions. The highest IWN is concerned with countries of the desert climate (Sudan and Egypt) and the lowest is concerned with countries of humid climate (DR Congo, Ethiopia, Uganda and S. Sudan). The water save percentage, as a result of rainfall, is the highest in humid countries such as DR Congo, Ethiopia and Uganda (Table 9) while that of Egypt or Sudan was nil because of the very low or absent rainfall. This reveals that crop production in Sudan and Egypt, based on rainfall, is not possible and irrigation is very essential.

3.2 Irrigation Water Needs for Maize and Cotton

Maize (*Zea mays*) and cotton (*Gossypian hirsutum*) are two main crops commonly cultivated in the countries of Nile basin. While maize is moderately sensitive to salinity, cotton is tolerant to salinity. Both are considered of high importance because they contribute economically for the benefits of the farmers and countries in general. Both have high irrigation water demands because both are summer field crops. Tables 10 and 11 represent data about the variations in crop evapotranspiration (ET_{crop}) and irrigation water needs (IWN). It is clear that the IWN for maize is lower than that of cotton. It is also clear that rainfall contributes, with different percentages, in water supply to plants.

Table 8. Mean values of ETo and ETcrop (mm/day) at the four growth stages of sorghum grown in countries of Nile basin*

Country	ET_o				ET_{crop}			
	1	2	3	4	1	2	3	4
Burundi	4.64	4.64	5.36	5.36	1.62	3.48	5.90	3.48
DR Congo	4.82	4.82	4.64	4.64	1.69	3.62	5.10	3.02
Egypt	5.64	6.06	6.27	6.69	1.97	4.55	6.90	4.35
Eritrea	5.27	5.46	5.66	5.66	1.84	4.10	6.23	3.68
Ethiopia	4.82	4.82	4.99	4.99	1.68	3.62	5.99	3.24
Kenya	4.64	4.64	4.64	4.64	1.62	3.48	5.10	3.02
Rwanda	4.64	4.64	5.36	5.36	1.62	3.48	5.90	3.48
Sudan	5.33	5.52	5.70	5.72	1.87	4.14	6.27	3.72
S. Sudan	4.89	5.10	5.21	5.21	1.71	3.83	5.73	3.39
Tanzania	4.64	4.64	5.20	5.20	1.62	3.48	5.72	3.83
Uganda	4.64	4.64	5.10	5.10	1.62	3.48	5.61	3.32

* FAO (1997)

Table 9. Mean values of ET_{crop}, IWN of sorghum and water saved in each country

Country	ET_{crop} (mm/TGP)	IWN (mm/TGP)	Water saved	
			mm/TGP	% of ET_{crop}
Burundi	477	277	200	41.9
DR Congo	450	230	220	48.9
Egypt	582	582	0	00.0
Eritrea	519	463	53	10.2
Ethiopia	459	239	220	47.9
Kenya	430	350	80	18.6
Rwanda	477	337	140	29.4
Sudan	524	524	0	00.0
S. Sudan	480	180	300	62.5
Tanzania	475	287	188	39.6
Uganda	460	240	220	47.8

Values of the quantity of water saved, as a result of rainfall contribution in water needs of plants, varied among countries, and were the highest with respect to Burundi, DR Congo, Ethiopia, Kenya, Rwanda, Tanzania, Uganda and S. Sudan for both maize and cotton plants. On the other hand, Egypt and Sudan are considered countries suffering severe rainfall water shortage and 100% of the IWN must supplied be from irrigation. Thus, the water saved as a result of satisfactory amounts of rainfall can contribute positively towards water supply to both Egypt and Sudan.

CONCLUSION

The rainfall in the Nile River basin is the highest in the humid region (mean value of 1000 mm/year) and the lowest in the semi-arid and desert region (mean value of 20 mm/year or less). As a result, the irrigation potential varies markedly among the countries of the Nile basin. The water withdrawals as percentage of renewable water are 5.0 for Burundi, 0.0 for DR Congo, 92.0 for Egypt, 5.0 for Eritrea, 2.0 for Ethiopia, 3.0 for Kenya, 1.0 for Rwanda, 56.0 for Sudan and 1.0 for Uganda. According to the quantities of annual renewable water sources; water management in the countries of Nile basin is considered very poor and therefore proper strategy for renewable water and irrigation water management are required for attaining an expansion in the cultivated lands for fodder and food production.

Irrigation water need (IWN) based on the data obtained (ETo, ETcrop, and Pe) by using the "Blaney Criddible" method improved the occurrence of wide variations in IWN by sorghum plant cultivated in the countries of Nile basin. The mean values of IWN are the highest for Egypt and Sudan (582 and 524 mm/ TGP, respectively). Because of the high rainfall (in the humid region), the water expected to be saved from irrigation as percentage of ET crop are 48.9, 47.9 and 47.8 for DR Congo, Ethiopia and Uganda, respectively. Similar data are presented for maize and cotton in these countries. It can be suggested, therefore, that a plenty of renewable water, reaching the cultivated lands from rainfall, in the humid region of the continent, can be saved for irrigation of the cultivated lands of the semi-arid and desert regions in Egypt and Sudan.

Table 10. Mean values of ET_{crop}, IWN of maize and water saved in each country

Country	ET_{crop} (mm/TGP)	IWN (mm/TGP)	Water saved	
			mm/TGP	% of ET_{crop}
Burundi	589	339	250	42.4
DR Congo	612	362	250	40.9
Egypt	716	716	0	00.0
Eritrea	648	563	85	13.1
Ethiopia	589	339	250	42.4
Kenya	589	214	275	46.7
Rwanda	589	249	250	42.4
Sudan	677	677	0	00.0
S. Sudan	589	289	300	50.9
Tanzania	589	289	300	50.9
Uganda	589	289	300	50.9

Table 11. Mean values of ET_{crop}, IWN of cotton and water saved in each country

Country	ET_{crop} (mm/TGP)	IWN (mm/TGP)	Water saved	
			mm/TGP	% of E_{crop}
Burundi	684	384	300	43.8
DR Congo	711	411	300	42.2
Egypt	868	868	00	00.0
Eritrea	749	644	100	13.4
Ethiopia	644	344	300	46.6
Kenya	684	374	330	48.3
Rwanda	684	684	300	43.9
Sudan	832	532	00	00.0
S. Sudan	644	344	300	46.6
Tanzania	684	384	300	43.9
Uganda	644	344	300	46.6

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الملخص العربي

استراتيجية الاحتياجات المائية لنباتات رئيسية تزرع فى دول حوض نهر النيل

إبراهيم حسين السكرى، علاء فاروق أبو كيلة

تتدفق مياه حوض نهر النيل من الجنوب إلى الشمال عبر 35 درجة لخطوط العرض والذى يمتد من المنطقة الرطبة إلى المنطقة الصحراوية. وتقع دول بورندى، الكونغو الديموقراطية، مصر، ارتريا، اثيوبيا (الحبشة)، رواندا، جنوب السودان، السودان، تنزانيا، أوغندا فى نطاق حوض النهر. ويوجد تفاوت كبير فى المعدل السنوى لسقوط الأمطار بهذه الدول حيث يتراوح فى المتوسط من 1000 مم/سنة فى دول المناطق الرطبة (بورندى والكونغو الديموقراطية) إلى أقل من 20 مم/سنة فى دول المناطق النصف صحراوية والصحراوية (السودان ومصر). وتبلغ كمية المياه المستخدمة من ماء النيل فى الرى معبراً عنها كنسبة مئوية فى دول حوض أنهار كالآتى: 0.5 بورندى، 0.0 الكونغو الديموقراطية، 92.0 فى مصر، 5.0 فى اريتريا، 2.0 فى اثيوبيا، 3.0 فى كينيا، 1.0 فى رواندا، 56.0 فى السودان، 1.0 فى تانزانيا، 0.0 فى أوغندا.

يحصل النبات على احتياجاته المائية إما من الأمطار أو الرى أو بالتوافق بينهما. ويمكن حساب حاجة النبات من ماء الرى عن طريق الفرق بين الاحتياجات المائية للنبات (البخر نتح للمحصول) والكمية الفعالة من المطر. وقد استخدمت طريقة "بلانرى – كريدل" لحساب البخر نتح المرجعى ومعامل المحصول فى حساب كمية حاجة النبات من ماء الرى وقد أتخذ نبات الذرة الرفيعة كمثال. وتوضح النتائج المتحصل عليها أن أعلى كمية من حاجة النبات من ماء الرى كانت خاصة بمصر والسودان (582، 524 مم/طول فترة النمو على التوالى) وأقل كمية كانت خاصة بالكونغو الديموقراطية، إثيوبيا، أوغندا وجنوب السودان(230، 239، 240، 180 مم/طول فترة النمو على التوالى).

قدرت كمية مياه النيل الممكن ادخارها وتوفيرها من مياه الرى لعدد من الدول وذلك فى حالة إتباع إدارة مناسبة للمياه المتجددة فى حوض النهر وكانت كالآتى معبراً عنها كنسبة مئوية من استهلاك كل دولة من الماء: 41.9 فى بورندى، 48.9 فى الكونغو الديموقراطية، 47.8 فى أوغندا، 62.5 فى جنوب السودان على التوالى. هذه النسبة من الماء يمكن إضافتها إلى ما يخص دول فقيرة فى مصادر الماء العذب المتجدد كما فى حالة مصر والسودان.