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Determination of Irrigation Regime of Wheat using Cropwat in the Blue Nile Basin, Ethiopia

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Abstract

Population growth, high water competition (demand), and the effect of climate change have caused water shortage problems in the Nile basin. Therefore, improving water management and determine the water requirement of field crops is substantial. In this study, the Food and Agricultural Organization (FAO) CROPWAT 8.0 simulation model, local climate, and soil data were used to determine crop water requirement (CWR) and irrigation scheduling of wheat crop at Koga and Rib irrigation scheme. The CROPWAT Penman-Monteith and the United States Department of Agriculture (USDA) soil conservation service method were used to compute the reference evapotranspiration (ETo) and effective rainfall respectively. The result of the study showed that reference evapotranspiration was varied from 4.86 mm day^{-1} (maximum) to 3.14 mm day^{-1} (minimum) at Koga while at Rib it ranges from 4.67 mm day^{-1} (maximum) to 2.36 mm day^{-1} (minimum) during the study period. The effective rainfall was 156.5 mm at Koga and 160.5 mm at the Rib irrigation scheme. The irrigation requirement of wheat at Koga was 376.9 mm dec^{-1} while at Rib was 379.9 mm dec^{-1}. The study showed that the CROPWAT model is an important tool to compute the crop water requirement of field crops in irrigated agriculture.

Keywords: Irrigation scheduling • Crop water requirement • Wheat • Koga • Rib

Introduction

Water is the main production inputs in agriculture to maintain the development of irrigation agriculture [1]. Irrigated agriculture plays an important role in food security, poverty reduction, and economic growth, thus effective management is an important issue in an irrigation system. Comprehensive irrigation water management practices are essential to improve water management and eliminate the associated problems [2]. Agriculture is the backbone of Ethiopia but most of the cultivated land is under a rain-fed agriculture system [3]. Even though Ethiopia has abundant water resources from precipitation, surface, and subsurface source, it suffered from severe drought, high temporal and spatial variations of water resources for the last four decades. Farmers in Ethiopia produce crops under high spatial and temporal variation of rainfall which causes cop production failures [4].

The population is growing rapidly and is expected to continue growing, which inevitably leads to increased food demand [5]. Farmers in Ethiopia face challenges including high competition for water, unpredictable rainfall, limited financial capacity, and climate change. By realizing such challenges, the government of Ethiopia takes initiation and allocating huge investments for irrigation infrastructure development during the last two decades [6]. Tana Beles, Megech, Koga, and Rib are some of the irrigation projects located in the Blue Nile Basin, Ethiopia.

Appropriate water (crop water requirement) application in crops production can improve nutrient availability, prevent land degradation, improve crop yield and water use efficiency [7]. It improves the moisture content of the fruit, survival rate, and better fruit test. Soil moisture conditions affect nutrient availability to the crops. Good irrigation management is critical for wheat productivity, a significant grain yield and tillers were observed using optimal and suboptimal crop water requirements [8]. The proper amount and timing of irrigation water applications is a crucial decision for a farm manager to prevent yield loss and maximize the irrigation water use efficiency [9]. Crop water requirements are the depth of water needed to meet the water loss through evapotranspiration, being disease-free, growing in large fields under non-restricting in soil, water, and fertility, and achieving full production potential under the given growing environment [10].

Several empirical methods were developed around the world from the simplest and oldest (Blaney Criddle method) to the most recent and accurate (FAO Penman-Monteith method) to determine crop water requirement ranging. The Penman-Monteith method has been recommended as the appropriate combination method to determine reference evapotranspiration based on climatic data [11]. CROPWAT

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is a tool developed by FAO used for irrigation planning and management and is widely used to estimate reference evapotranspiration and crop water requirement [12]. It allows for the development of improved irrigation practices, planning of irrigation schedules, and assessment of production under rained/irrigation conditions [13].

Irrigation agriculture is widely expanded in the Blue Nile basin like Koga and Rib irrigation schemes. Farmers can irrigate crops based on traditional know-how causing nutrient leaching, waterlogging, and severe water shortage problems in the study area. Wheat is the most dominantly cultivated cereal crop under irrigation in the Koga irrigation command area while at Rib is the newly introduced cereal crop by farmers [14]. However, crop water requirements and irrigation schedules of wheat were not done in the study site (Koga and Rib) irrigation scheme. Therefore, the objectives of this study were to determine the crop water requirement and irrigation scheduling of wheat using the CROPWAT model for optimal resource allocation and to increase yield and water productivity.

Materials and Methods

Study area description

Koga irrigation scheme is located in the Tana Basin under Mecha district, south of the Amhara Region, Ethiopia. It lies between 11°20' to 11°32' North Latitude and 37°02' to 37°11' East Longitude. Koga irrigation scheme is located 41 km to the West of Bahir Dar city and 543 km to the North of the capital city, Addis Ababa at 37°7'29.72" Easting and 11°20'57.85" Northing and 1953 m a.s.l. The average annual rainfall of the area is 1124 mm. The mean maximum and minimum temperatures are 26.8°C and 9.7°C respectively (Figure 1). Rib irrigation scheme is located inside Tana Basin in Fogera district Northwest of Ethiopia, 60 kilometers to the East of Bahir Dar city and 648 km North of the capital city, Addis Ababa at 37°25' to 37°58' Easting and 11°44' to 12°03' Northing and an altitude of 1803 m. It receives 1400 mm mean annual rainfall. The mean daily maximum and minimum temperature of the area is 30°C and 11.5°C.

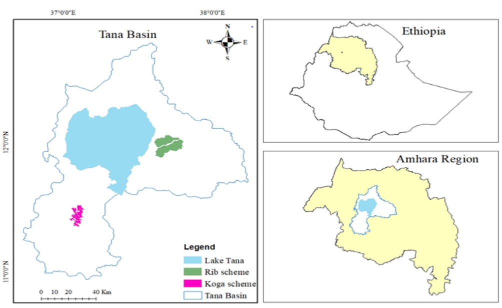

Figure 1. Location of the study site.

Methods

Local rainfall data, reference Evapotranspiration (ETo), soil data, and crop data have used as an input for the CROPWAT model. Crop water requirement and irrigation water requirement were computed using the CROPWAT 8.0 model. Climate data for sixteen years (2000-2016) for the Koga irrigation scheme were taken from Koga and Bahir Dar meteorological stations while for the Rib irrigation scheme Addis Zemen meteorological station was used. The crop data for wheat (root depth, crop coefficient, critical depletion, yield response factor, and length of plant growth stage) was obtained from FAO irrigation and drainage paper 56 [15]. The planting date under irrigation in the study area was started in mid-November. Information on soil properties i.e., Field Capacity (FC), Permanent Wilting Point (PWP), infiltration rate, initial soil moisture depletion were done at Adet Agricultural Research Center soil laboratory using the gravimetric method. Reference Evapotranspiration (ETo), the crop Evapotranspiration (ETc), and irrigation water requirement (IWR) were estimated using FAO penman-Monteith method; equations 1, 2, and 3 respectively. The United States Department of Agriculture (USDA) Soil Conservation Service method was used for the estimation of effective rainfall.

$$ETo=\frac{0.408\Delta(Rn-G)+\gamma\frac{900}{T+273}U2(es-ea)}{\Delta+\gamma(1+0.34U2)} \quad (1)$$

Where: ETo=reference evapotranspiration (mm day^{-1}), Rn=net radiation at the crop surface (MJ m^{-2} day^{-1}), G=soil heat flux density (MJ m^{-2} day^{-1}), T=mean daily air temperature (°C), U_2=wind speed at 2 m height (m s^{-1}), es=saturation vapour pressure (kPa), ea=actual vapour pressure [kPa], es-ea=saturation vapour pressure deficit (kPa), Δ=slope vapour pressure curve (kPa °C^{-1}), γ=psychrometric constant (kPa °C^{-1}).

The Crop Water Requirement (CWR) is the water lost from a cropped field through Evapotranspiration (ET) and it is expressed as the rate of ET in mm/day. The CWR is derived from crop Evapotranspiration (ETc) and estimated by the following equation [16]. The differences in crop Evapotranspiration (ETc) during the growth stages, crop coefficient (Kc) for wheat were varied over the development stage (initial development, mid-season, and late-season) [17]. Irrigation scheduling determines when and how much irrigates the specific field crop.

ETc=ETo × Kc Reference Crop Evapotranspiration (mm day^{-1}) (2)

Kc=Crop coefficient

The irrigation requirement (IR) is the main parameter for the planning, design, and operation of irrigation and water resources systems [18]. It is important to the optimal allocation of water resources for policy and decision-maker during the operation and management of irrigation systems. Missed management of irrigation requirements may lead to inappropriate capacities storage reservoirs, low water use efficiency, reduction of the irrigated area, and increased development costs [19]. The irrigation requirement is therefore determined by the following equation.

IRn=ETc-(Pe+Ge+Ws)+LR (3)

Where, IRn=Net irrigation requirement (mm), ETc=Crop evapotranspiration (mm), Pe=Effective dependable rainfall (mm), Ge=Groundwater contribution from water table (mm), Ws=Water stored in the soil at the beginning of each period (mm) and LR=Leaching requirement (mm).

Results and Discussions

The soil sample was taken before the planting of wheat takes place and analyzed using laboratory procedure. The particle size of the sample was determined using the hydrometer method [20]. The result as shown the soil texture was varied in the study site (Table 1). Data of wheat planting and harvesting date, critical depletion level, root depth, crop growing period (Table 2), and soil characteristics of the study area (Table 1) were used to compute crop evapotranspiration.

Site	FC (%)	WP (%)	Sand (%)	Silt (%)	Clay (%)
Koga	30.8 ± 1.7	18.9 ± 1.2	20.2 ± 4.8	22.4 ± 2.7	57.3 ± 4.5
Rib	59.0 ± 1.3	21.0 ± 1.4	24.0 ± 2.4	36.0 ± 3.5	40.0 ± 5.2

Table 1. Soil characteristics of the study area.

Crop	Planting and Harvesting Date	Root depth (m)	Depletion fraction (P)	Yield response factor (Ky)			
				Initial	Development	Middle	Late
Wheat	Mid-November	0.6-1.5	0.55	0.2	0.6	0.5	0.5

Table 2. Input data CROPWAT model in the study area.

Month	Temperature (°C)		Relative Humidity (%)	Wind speed (km day^{-1})	Sunshine hours	Radiation (MJ/m^2/day)	ETo (mm/day)
	Min	Max					
January	8.2	27.1	48	61	9.5	20.9	3.45
February	10	29.1	43	69	9.7	22.6	4.01
March	12.7	30.1	41	86	9.2	23.3	4.56
April	14.4	30.3	42	95	9.1	23.6	4.86
May	15.2	29.7	52	86	8.5	22.3	4.62
June	14.2	27.8	66	86	6.9	19.5	4
July	14	24.4	76	69	4.6	16.2	3.21
August	13.9	24.8	84	69	4.6	16.4	3.14
September	13.4	25.8	73	69	6.3	18.8	3.57
October	13.7	26.8	64	69	8.7	21.4	3.96
November	11.2	26.9	57	61	9.7	21.4	3.72
December	8.5	26.8	52	61	9.7	20.6	3.41
Average	**12.4**	**27.5**	**58**	**73**	**8**	**20.6**	**3.88**

Table 3. Climate characteristics of Koga irrigation scheme

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The reference Evapotranspiration (ETo) obtained using the input data at the Koga irrigation scheme was high between February and June (4.0–4.86 mm day^{-1}) due to the high temperature (Table 3). It decreases after July and the lowest value was 3.14 mm day^{-1} in August due to low temperature in the area. The average reference evapotranspiration was 3.88 mm day^{-1} (Table 3). The reference evapotranspiration value at Rib irrigation scheme shown that, a high evaporation rate was observed in March (4.67 mm day^{-1}) while the lowest evaporation (2.36 mm day^{-1}) was recorded in July (Table 4). In the study area June, July, August, and September are the rainy seasons. The lowest rainfall and effective rainfall was observed starting from November to May (Table 5). The average rainfall of the last sixteen years (2000–2017) was used as input and the USDA soil conservation service was applied to estimate effective rainfall and to compute the wheat water requirement and irrigation scheduling. The average annual rainfall at Koga and Rib irrigation scheme were 874.3 mm and 1032.0 mm while the effective rainfall was 539.2 mm 623.1 mm respectively (Table 5). The monthly reference evapotranspiration (ETo) exceeds the monthly rainfall from January to May and from November to December on both location (Figure 2 and Figure 3). These indicate that irrigation water is substantial during these months in the study area.

Month	Temperature (°C)		Relative Humidity (%)	Wind speed (km day^{-1})	Sunshine hours	Radiation (MJ/m^2/ day)	ETo (mm/day)
	Min	Max					
January	9.8	27.7	67	156	8.3	19.1	3.57
February	10.8	29.5	63	156	9.3	21.9	4.25
March	11.8	29.7	60	147	9.2	23.2	4.67
April	12.1	29.2	59	130	8.3	22.3	4.57
May	12.1	29.5	71	156	6.8	19.8	4.12
June	12	26.8	86	156	5.6	17.7	3.37
July	12.1	23.7	94	104	2	12.4	2.36
August	12	24	95	86	2.2	12.8	2.4
September	11.6	25.2	91	104	6.7	19.4	3.38
October	10.8	27.2	82	138	8.4	20.9	3.69
November	10.3	27.2	77	138	9.1	20.4	3.56
December	10.3	27.6	71	112	8.8	19.2	3.4
Average	**11.3**	**27.3**	**76**	**132**	**7.1**	**19.1**	**3.61**

Table 4. Climate characteristics of Rib irrigation scheme.

Month	Rainfall (mm)		Eff. Rainfall (mm)	
	Koga	**Rib**	**Koga**	**Rib**
January	0	6	0	5.9
February	0	2	0	2
March	0.1	0	0.1	0
April	0	11	0	10.8
May	7.3	32	7.2	30.4
June	122	110	98.2	90.6
July	314.8	355	156.5	160.5
August	274.4	319	152.4	156.9
September	137.9	129	107.5	102.4
October	17.8	51	17.3	46.8
November	0	13	0	12.7
December	0	4	0	4
Total	874.3	1032	539.2	623.1

Table 5. Rainfall and effective characteristics of the study irrigation scheme.

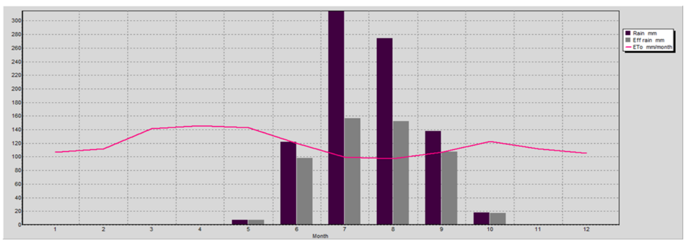

Figure 2. Reference evapotranspiration (ETo), rainfall and effective rainfall at Koga scheme.

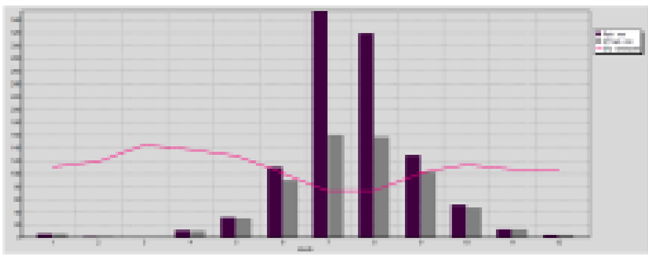

Figure 3. Reference evapotranspiration (ETo), rainfall and effective rainfall at Rib scheme.

Crop water requirement

The monthly water requirement and irrigation requirement of wheat planted in mid-November shown that crop water demand in both locations was varied within the same month. The maximum crop water requirement was obtained in February which was 46.3 mm dec^{-1} at Koga and 50.2 mm dec^{-1} at Rib irrigation scheme (Table 6 and Table 7). This variation comes from high-temperature variation between the two study sites (Table 4 and Table 3).

Month	Decade	Stage	Kc (Coeff.)	ETc (mm/day)	ETc (mm/dec)	Eff rain (mm/dec)	Irr. Req. (mm/dec)
Nov	2	Init	0.3	1.12	6.7	0	6.7
Nov	3	Init	0.3	1.09	10.9	0	10.9
Dec	1	Init	0.3	1.05	10.5	0	10.5
Dec	2	Dev	0.36	1.23	12.3	0	12.3
Dec	3	Dev	0.64	2.2	24.2	0	24.2
Jan	1	Dev	0.94	3.24	32.4	0	32.4
Jan	2	Mid	1.15	3.96	39.6	0	39.6
Jan	3	Mid	1.16	4.21	46.3	0	46.3
Feb	1	Mid	1.16	4.42	44.2	0	44.2
Feb	2	Mid	1.16	4.63	46.3	0	46.3
Feb	3	Late	1.08	4.53	36.2	0	36.2
Mar	1	Late	0.83	3.62	36.2	0	36.2
Mar	2	Late	0.54	2.47	24.7	0	24.7
Mar	3	Late	0.34	1.6	6.4	0	6.4
Total					**377**	**0.1**	**376.9**

Table 6. Crop water requirement and irrigation requirement of wheat at Koga irrigation scheme.

Month	Decade	Stage	Kc (Coeff.)	ETc (mm/day)	ETc (mm/dec)	Eff rain (mm/dec)	Irr. Req. (mm/dec)
Nov	2	Init	0.3	1.07	6.4	1.9	4.9
Nov	3	Init	0.3	1.05	10.5	2.5	8
Dec	1	Init	0.3	1.04	10.4	2	8.4
Dec	2	Dev	0.36	1.23	12.3	0.9	11.4
Dec	3	Dev	0.65	2.25	24.8	1.2	23.6
Jan	1	Dev	0.96	3.38	33.8	1.9	31.8
Jan	2	Mid	1.17	4.18	41.8	2.2	39.6
Jan	3	Mid	1.18	4.48	49.3	1.7	47.6
Feb	1	Mid	1.18	4.75	47.5	1.1	46.5
Feb	2	Mid	1.18	5.02	50.2	0.6	49.6
Feb	3	Late	1.1	4.85	38.8	0.4	38.4
Mar	1	Late	0.84	3.82	38.2	0	38.2
Mar	2	Late	0.55	2.57	25.7	0	25.7
Mar	3	Late	0.34	1.6	6.4	0	6.3
Total					**396.1**	**16.5**	**379.9**

Table 7. Crop water requirement and irrigation requirement of wheat at Rib irrigation scheme.

Net irrigation requirement and irrigation scheduling

An optimal irrigation water requirement and irrigation schedule improves irrigation management in the field. Effective irrigation management is managing the amount of water applied and timely application of water efficiently. In the study area, farmers applied irrigation water through furrow irrigation (dominantly) and flooding irrigation (minor) systems. The application efficiency in the study area was taken as 70% to determine irrigation requirements. The total gross and net irrigation water requirement for wheat at the Koga irrigation scheme was 529.2 mm and 370.5 mm respectively while at the Rib irrigation scheme was 635.8 mm and 445 mm respectively (Tables 8 and 9) (Figure 4,5).

Date	Day	Stage	Rain (mm)	Ks (fract.)	Eta (%)	Depl (%)	Net Irr (mm)	Deficit (mm)	Loss (mm)	Gr. Irr (mm)	Flow (l/s/ha)
28-Dec	44	Dev	0	1	100	56	58	0	0	82.8	0.22
18-Jan	65	Mid	0	1	100	56	70.7	0	0	101	0.56
4-Feb	82	Mid	0	1	100	57	71.9	0	0	102.7	0.7
20-Feb	98	Mid	0	1	100	58	72.8	0	0	104	0.75
20-Mar	126	End	0	1	100	77	97.1	0	0	138.7	0.57
24-Mar	End	End	0	1	0	4					

Table 8. Irrigation scheduling of wheat at Koga irrigation scheme.

Date	Day	Stage	Rain (mm)	Ks (fract.)	Eta (%)	Depl (%)	Net Irr (mm)	Deficit (mm)	Loss (mm)	Gr. Irr (mm)	Flow (l/s/ha)
28-Nov	14	Init	0	0.82	92	64	45.1	0	0	64.5	0.53
12-Dec	28	Init	0	1	100	26	24.3	0	0	34.7	0.29
26-Dec	42	Dev	0	1	100	29	33.5	0	0	47.9	0.4
9-Jan	56	Dev	0	1	100	37	50.4	0	0	72	0.6
23-Jan	70	Mid	0.9	1	100	40	57.9	0	0	82.6	0.68
6-Feb	84	Mid	0	1	100	44	63	0	0	90	0.74
20-Feb	98	Mid	0	1	100	48	68.6	0	0	98	0.81
6-Mar	112	End	0	1	100	43	61.3	0	0	87.6	0.72
20-Mar	126	End	0	1	100	28	40.9	0	0	58.5	0.48
24-Mar	End	End	0	1	0	3					

Table 9. Irrigation scheduling of wheat at Rib irrigation scheme.

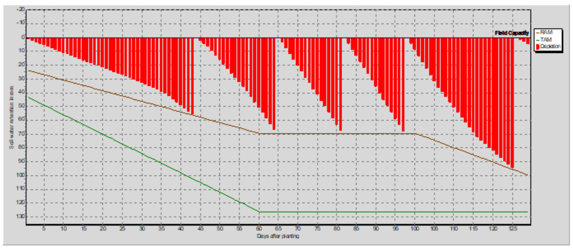

Figure 4. Irrigation scheduling of wheat at Koga irrigation scheme.

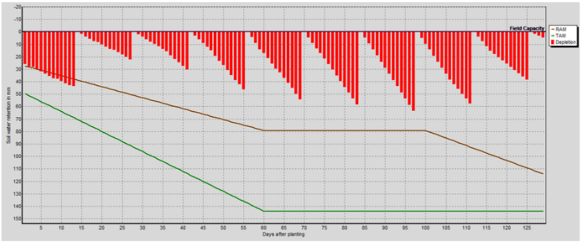

Figure 5. Irrigation scheduling of wheat at Rib irrigation scheme.

The crop needs optimal moisture conditions to achieve maximum yield. The Total Available Moisture (TAM) and Readily Available Moisture (RAM) are media that the plant can get from the root zone with no water stress. The result showed that the crop water requirement of wheat varies in place, month, and growth stage in the study area. In general optimal irrigation application considering soil water holding capacity and crop water requirement (especially during critical stages of wheat) is essential to improve water shortage problems and to enhance yield and water productivity of the study area.

Conclusion

This study showed that monthly crop water requirement and irrigation water requirement of wheat have high spatial and temporal variation. Simulation of crop water requirement and scheduling of wheat using the CROPWAT model was specific to the study area owing to a high seasonal and spatial variation. The study will help to improve the management of water resources and the productivity of wheat. CROPWAT tool can help to assess crop water requirement and irrigation scheduling of field crops in areas where water resource is limited. This study may a reference for decision-making for future planning.

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References

1. Abate, Zewdie. “Water resources development in Ethiopia: an evaluation of present experience and future planning concepts." *Ithaca press* 13 (1994): 169-199.
2. Tewabe, Dires, Abebe Atakltie, Enyew Alebachew, and Amare Tsige. "Determination of bed width on raised bed irrigation technique of wheat at Koga and Rib Irrigation Projects, North West, Ethiopia." *Cog Food Agricult 6* (2020): 1712767.
3. Al-Kaisi, Mahdi M, Berrada Abdel, and Stack Mark. "Evaluation of irrigation scheduling program and spring wheat yield response in southwestern Colorado." *Agri water manage* 34 (1997): 137-148.
4. Allen, Richard G, Pereira Luis S, Raes Dirk, and Smith Martin. "Crop evapotranspiration-Guidelines for computing crop water requirements-FAO Irrigation and drainage paper 56." *Fao Rome* 300 (1998): D05109.
5. Awulachew, Seleshi Bekele. "Irrigation potential in Ethiopia: Constraints and opportunities for enhancing the system." *Gates Open Res* 3 (2019): 22.
6. Derib, Sisay Demeku, Descheemaeker Katrien, Haileslassie Amare, and Amede Tilahun. "Irrigation water productivity as affected by water management in a small-scale irrigation scheme in the Blue Nile basin, Ethiopia." *Experiment Agri* 47 (2011): 39-55.
7. Awulachew, Seleshi Bekele, and Mekonnen Ayana. "Performance of irrigation: An assessment at different scales in Ethiopia." *Experiment Agri* 47 (2011): 57-69.
8. Bouyoucos, George John. "Hydrometer method improved for making particle size analyses of soils 1." *Agronom J* 54 (1962): 464-465.
9. Choudhury, PN, Kumar Vijay. "The sensitivity of growth and yield of dwarf wheat to water stress at three growth stages." *Irrigat Sci* 1 (1980): 223-231.
10. Narmilan, A, Sugirtharan M. "Application of FAO-CROPWAT Modelling on Estimation of Irrigation Scheduling for Paddy Cultivation in Batticaloa District, Sri Lanka." *Agri Rev* 42 (2021):73-79.
11. Rosegrant, Mark W, Binswanger Hans P. "Markets in tradable water rights: Potential for efficiency gains in developing country water resource allocation." World develop 22 (1994): 1613-1625.
12. Doorenbos, J, Pruitt WO. "Crop water requirements. FAO irrigation and drainage paper 24." Land Water Develop Divi FAO Rome 144 (1977):1-9.
13. Ewaid, Salam Hussein, Abed Salwan Ali, Al-Ansari Nadhir. "Crop water requirements and irrigation schedules for some major crops in Southern Iraq." Water 11 (2019): 756.
14. Gaafer, SA, Refaie KM. "Modeling water effects on growth and yield of melon cv. reticulates." *Egypt J Bas Appl Sci* 21 (2006): 682-693.
15. Mozumdar, Lavlu. "Agricultural productivity and food security in the d eveloping world."Bangla *J Agricult Econom* 35 (2012): 53-69.
16. Muktar, BeniamYaziz, Yigezu TesfayeTefera. "Determination of optimal irrigation scheduling for maize (Zea Mays) at Teppi, Southwest of Ethiopia." *Irrig Drain Syst Eng* 5 (2016): 173.
17. Raviv, Michael, Blom Theo J. "The effect of water availability and quality on photosynthesis and productivity of soilless-grown cut roses." Sci Horticult 88 (2001): 257-276.
18. Chen, Abraham Anthony, Falloon Trevor, Taylor Michael. "Monitoring agricultural drought in the West Indies. Monitoring and Predicting Agricultural Drought: A Global Study. " Oxford Uni Press, New York (2005): 144-155.
19. Panin, Anthony, Brokken Ray F. "Economic analysis of cow traction farm technology in the Ethiopian Highlands." Rec Dévelop Trac Anima Afriq Ouest (1993): 221.
20. Tewabe, Dires, Abebe Atakltie, Enyew Alebachew, and Tsige Amare. "Determination of bed width on raised bed irrigation technique of wheat at Koga and Rib Irrigation Projects, North West, Ethiopia." *Cogent Food Agri* 6 (2020): 1712767.

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