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Crop Evapotranspiration, Irrigation Water Requirement And Irrigation Scheduling Of Soybeans Under Sprinkler Irrigation System At Nasho Sector, Rwanda

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Abstract – The study aimed to estimate the Crop Water Requirement of Soybean plant under sprinkler irrigation system at Nasho Sector, Rwanda. Experimentally, the study covered the total area of 30mx60m to give 1800m^2. It means that each plot contained 10m width versus 60m height with one installed movable sprinkler. While for water collection from nozzles, catch cans were used to collect the discharge rate. After pumping water to sprinklers, the research should pass 15min and record the discharge rate in each experimental plot for 3 catch cans in each sub plots to make 3plots*3 catch cans* 3sub plots and give 27 water samples for whole experimental site. The Cropwat 8 computer packages was used to compute Reference evapotranspiration, Crop water Requirement and irrigation scheduling in sprinkler irrigation installed for soybeans production. The study findings showed that the mean ETo of soybean was found to be 4.79 mm/day. For crop water requirement, it was found that the total of rain fall was 785.2mm while the effective rain fall was found to be 678.8mm for the period of twelve months. For irrigation scheduling, It was found that the total Crop evapotranspiration of soybean was 678.4mm/dec while effective rainfall need per soybean production was found to be 134.9 mm/dec and the Irrigation water requirement per soybean under sprinkler irrigation system was found to be 547mm/dec. It is concluded that that the total amount of water stored in soybean root zone is less than the total needed water and soy beans can suffer from water deficit. For crop water requirement, it was also found that the total of rain fall was higher than effective rain fall stored in root zone for the period of twelve months and these implies higher Crop water need and as results Maximum potential yield for most irrigated soybeans crops in the study area has increased substantially during the irrigated area with sprinkler system. In addition, there is an economic gains in soybean productivity that are attributed to improved plant management, modern irrigation practices associated to better agronomic management practices than those used in the past. It is also recommended that different riser heights may also be studied to observe their effect on the measures of sprinkler irrigation system performance, to cater for the cultivation of other crops.

Keywords – Crop Evapotranspiration, Crop Water Requirement, Irrigation Scheduling, Rwanda

I. INTRODUCTION

The world's population continue to rise while water is a limited resource, thus, it is becoming increasingly difficult to continue with current irrigation practices in arid and semi-arid region of the world (Hamdy *et al.*, 2003). Therefore, the sustainable use of water in irrigated agricultural systems with an emphasis on reducing water use requires careful planning and management. In spite of the low efficiency of surface irrigation, it is still the oldest and most used method of irrigation especially for clay soil in Egypt comparing with sprinkler irrigation which is considered an advanced irrigation technique for water-saving, cost effective of fertilizer use and in accurately controlling irrigation time and water amount (Dinar & Mody, 2004).

Irrigation is the artificial application of water to the soil or plant, in the required quantity and at the time needed. The art of irrigation can be achieved using watering cans, sprinklers, emitters, surface systems and many others. Irrigation is widely carried out through surface and pressurized systems, characterized by the mode of transport of the water onto the point of application (Keller & Bliesner, 1990). Referring to definition of different scholars, the art of irrigation is thus a risk management tool for agricultural production. The risk of yield reduction due to drought is minimized with irrigation, because moisture can be added to the soil to meet the water requirements of the crop.

Sprinkler irrigation is a class of pressurized irrigation method in which water is carried through a pipe system to a point neighboring where it will be consumed. A pressurized piped irrigation system is a network installation consisting of water pond, pumping unit, fittings and other devices properly designed and installed to supply water under pressure from the source of water to the destination irrigable area (Yoshida *et al.*, 2003). Sprinkler irrigation is suitable for most crops including maize, soybeans, bush beans and horticultural crops not only chili but also to snap beans, onions, carrots, cabbage and egg plants due to the availability of different range of discharge capacities. With the aid of sprinklers, water is sprayed through the air onto the soil surface or crop and the pattern of the spray simulates rainfall. In most of African countries, Soybean is considered one of the most important industrial nutrient products and suitable for sprinkler irrigation techniques.

Crop evapotranspiration (ETa) is an important parameter in hydrological, environmental and agricultural studies and plays a key role in designing and managing irrigation water management under irrigated agriculture. Although the measurement of crop ETa is directly linked to lysimeters and Eddy covariance systems, it is also estimated by the others methods like indirect method using reference crop evapotranspiration (ETo) and crop coefficients. The research of Jensen (1968) was the pioneer relating to crop actual evapotranspiration to the reference evapotranspiration using the conversion factor called crop coefficient (Kc) which is different for crops stages (initial, growing or development and end/ harvest) due to crop characteristics, soil moisture status and soil type, crop management practices, canopy and aerodynamic resistance, climatic conditions such as the available energy, surrounding air content in vapor and air vapor deficit (Jensen *et al.*, 1990, Djaman *et al.*, 2017). For more accurate of results, the commonly method used is Penman–Monteith reference evapotranspiration method for estimation of ETo among the numerous ETo equations developed and implemented (Allen *et al.*, 1998, Djaman *et al.*, 2015).

According to Sentelhas *et al.* (2010), Irrigation water requirement is a function of multi factors including weather data of the area. Net irrigation water requirement (NIWR) of the crop which is the quantity of water necessary for crop growth since the initial stage to harvesting and the quality of water utilized by the crops is optimum during the development stage. Information on irrigation efficiency is necessary to be able to transform NIWR into gross irrigation water requirement (GIWR), which is the quantity of water to be applied in reality, taking into account water losses.To cope with the aforementioned climatic conditions and the future projection, accurate estimation of crop water use may be a priority for water management and planning under conservative agriculture (Pereira *et al.*, 2015). Thus this study was carried out at Nasho irrigation scheme with the aim of estimating crop Evapotranspiration, Irrigation Water Requirement and Irrigation Scheduling of Soybeans under Sprinkler Irrigation system at Nasho GFI, Kirehe District and Eastern Province Rwanda and propose the feasible ways to reduces water losses in the irrigated areas.

II. 2. MATERIALS AND METHODS

Site description

The experimental site was in Nasho sector where found the Governmental Funded Irrigation (GFI) (30.50625E-30.54375E, 2.04375S-2.00625S; 1500 m above sea level) Eastern province of Rwanda (**Figure 1**). The region has semi-arid climate, with average mean minimum and maximum annual temperature of 16.7°C and 27.7°C mean. It has the annual rainfall of 785.1 mm (Mpanga station, 1989–2019). Annual potential evapotranspiration exceeds 600mm. Rainfall is distributed over two rainy seasons, one from Mid-February to mid-May and another from September to Mid-December, with precipitation peaks in April and November (**Figure 2**).

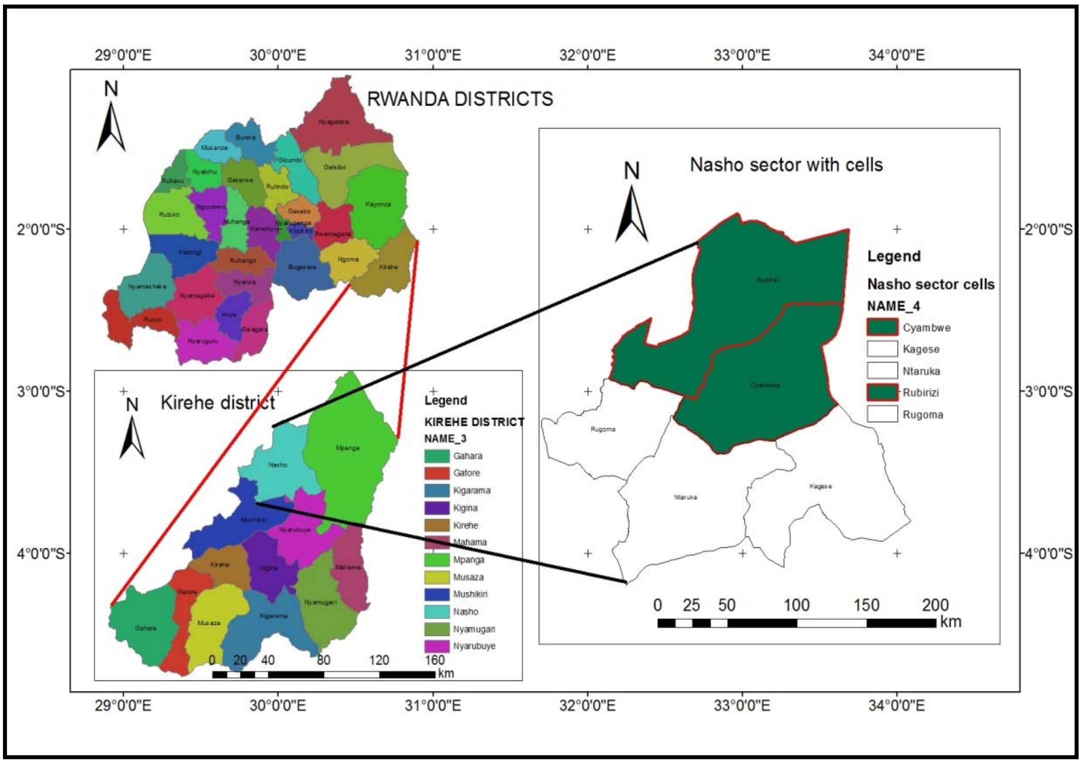

Figure 3: Nasho map indicating the study area under irrigation scheme

Source: Habineza *et al.* (2020)

Currently the total area under covered by new irrigation project is about 1,280 ha in Nasho sector, Kirehe District of Eastern Province, the figure below shows Nasho sector localization in the map of Rwanda and have been produced using Arc GIS 13.1 computer package.

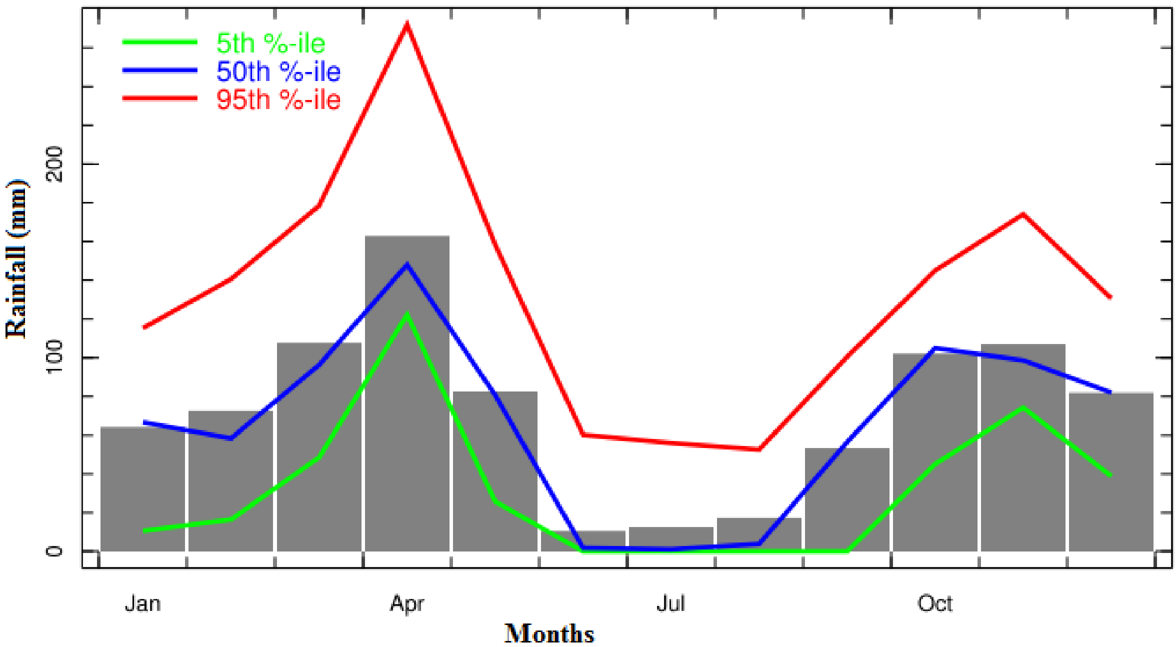

Figure 2: Rainfall climatology of Nasho Government Funded Irrigation

III. Methods

As the irrigation scheme covers the big area of 1,280 ha, the researchers have chosen the total area of 30mx60m to give 1800m^2. It means that each plot contained 10m width versus 60m height. In each selected experimental plot there was one pass of movable sprinkler system. While for water collection from nozzles, catch cans were used to collect the discharge rate. After pumping water to sprinklers, the research should pass 15min and record the discharge rate in each experimental plot for 3 catch cans in each sub plots to make 3plots*3 catch cans* 3sub plots and give 27 water samples for whole experimental (Discharge rate). It means that 9 catch cans were placed around one sprinkler in one plot at the same distance

2.1 Data analysis

The measured data were kept in a Microsoft Excel file and later using either SPSS 22.0 and STATA 13.0. Descriptive statistics like means, median, variance, standards deviation, minimum, maximum and coefficient of variation were used to interpret data. The Cropwat 8 computer package was used to compute Reference evapotranspiration, Crop water Requirement and irrigation scheduling in sprinkler irrigation installed for soybeans production.

IV. Results and Discussion

1. Estimation of Crop Water Requirement (CWR) for soybean by Cropwat 8

The computer software CROPWAT 8.0 was developed by FAO to estimate the crop water requirements, irrigation requirements of soybean and irrigation schedule at the experimental site using the input data like climate data, rainfall, crop data and soil data. The crop water requirement was worked out and expressed in millimetre per day. In irrigation practice, Crop water requirement is mainly a function of crop evapotranspiration which should be monitored in the mid-stages attributed to more crop water need owing to full canopy development in addition to evaporative demand. However, in the late stage, though there is not much variation in the atmospheric demand, the transpiration rate decreases due to decrease in physiological activity of plants. The determination crop water requirement relies effectively on the total precipitation and effective rainfall. The results related to Crop Water Requirement are now shown and discussed in section below:

2. Reference Evapotranspiration (ETo) of soybean crop

When rainfalls, part of the rainwater goes as runoff and another part of the water percolates down ward. The remaining part of water stored in the root zone is called effective rainfall and other portion is consumed by crops to produce evapotranspiration of the crop. The reference Evapotranspiration (ETo) is a function of min and max temperature, relative humidity, wind speed and sunshine duration. Based on the values of climate data using monthly rate, ETo calculated and solar radiation are shown in table 1below.

Table 1: Determination of Reference Evapotranspiration (ETo) under soybean crop

Month	Min Temp	Max Temp	Relative Humidity	Wind speed	Sunshine duration	Radiation	ETo
Unit	°C	°C	%	km/day	Hours	MJ/m²/day	mm/day
January	16.8	26.3	72	62	16.5	22.1	2.96
February	16.5	26.7	75	32	15.8	24.7	3.7
March	16.6	26.3	77	42	15.5	28.4	4.72
April	16.5	26.1	67	76	15.6	31.6	5.55
May	16.9	26.2	52	70	16.2	33.9	6.06
June	16.5	28.3	57	47	16.6	34.8	6.33
July	16.3	28.2	67	24	15.8	33.3	6.04

August	17.4	29.4	71	72	17.8	35.1	6.47
September	17.2	29.2	74	45	16.4	30.5	5.41
October	16.3	28.3	74	43	15.8	25.8	4.12
November	16.4	29.2	70	65	16.5	22.7	3.32
December	16.6	27.8	61	87	15.5	19.9	2.77
Average	**16.7**	**27.7**	**68**	**55**	**16.2**	**28.6**	**4.79**

Source: Author, 2020

The input of weather data like minimum and maximum temperature in ºC, relative humidity (%), wind speed (km/h), sun shine duration in hours/ day were fed into CROPWAT 8.0 computer package. The solar radiation (MJ/m²/day) and Reference evapotranspiration (ETo) were generated automatically. The results presented in table 1 revealed that monthly average mean of solar radiation were 28.6 MJ/m²/day while its range varies from 22.1MJ/m²/day to 35.1 MJ/m²/day. The difference between maximum and minimum solar radiation was found to be 13MJ/m²/day which is very high and this is the base of high evaporative rate of water. This will require the farmer to supply much water to compensate water deficit. The lowest solar radiation was recorded in December while the highest solar radiation was recorded in August. In addition, table 1 shows that the mean ETo from Nasho farm under soy bean farming was found to be 4.79 mm/day. Its range varies from 2.77 mm/day to 6.47 mm/day. The maximum ETo was found in the month August while the minimum was found in the month of December. The difference between maximum and minimum of ETo was found to be 3.7 mm/day. It means that the fact that there is a high difference mean in solar radiation, there is an effect of high evapotranspiration rate of soy bean which reflects high water needs for irrigation in the sunny period. Since the study area is conditioned with the higher temperature above 25ºC, this influence the highest crop evapotranspiration (Kc), soil water balance during the soybean development stage which leads to change in evaporation and plant transpiration. While, with the increasing temperature, lack of precipitation and soils water unavailability, crop production will likely to decrease through shortening the crop growth cycle while daily irrigation will be applied. The findings are consistent with research conducted by Bhatt and Hossain (2019) who reported that climate change impacted soil water balance and leads to change in evaporation and plant transpiration.

3. Total and Effective Rainfall of soy bean at GFI Nasho farm

When it is raining, some part of the rainwater goes as runoff and another part of the water percolates down ward to recharge the ground water table. The remaining part of water stored in the root zone is called effective rainfall. Based on the values of ETo calculated above, the total rain and effective rainfall for different months are shown in table 2 below.

Table 2: Total and Effective Rainfall of soy bean at Nasho farm

Months	Eto (mm/day)	Rain (mm)	Eff rain (mm)
January	2.96	67.7	60.4
February	3.7	48.6	44.8
March	4.72	97.7	82.4
April	5.55	149.5	113.7
May	6.06	68.4	60.9
June	6.33	25.6	24.5
July	6.04	22.2	21.4
August	6.47	29	27.6
September	5.41	42.8	39.9

October	4.12	78.6	68.7
November	3.32	99	83.3
December	2.77	56.3	51.2
Total	**4.79**	**785.2**	**678.8**

Source: Author, 2020

The mean monthly Reference evapotranspiration was computed and was found to be 4.79 mm/day. Its range varies from 2.77 mm/day to 6.47 mm/day. The maximum ETo was found in the month of August while the minimum was found in the month of December. The difference between maximum and minimum of ETo was found to be 3.7 mm/day. The total of rain fall was found to be 785.2mm while the effective rain fall was found to be 678.8mm for the period of twelve months. It means that total amount of water stored in soybean root zone of soy bean is less than to the total available water and soy beans can suffer from water deficit. It was also found that the maximum total rainfall and effective rainfall were found to be 149.5mm and 113.7 recorded in April while the minimum values were found to be 22.2mm and 21.4mm recorded in July respectively. It is an implication during July, more irrigation water should be taken into account to avoid plant stress. It shows that July is the driest month, which needs more irrigation to compensate the water needs of soybeans. Evapotranspiration (ET) is an imperative soil water balance component and is acting a major role in determining the potential yields in the agricultural sector. Once there is a higher evapotranspiration (ET), the decrease in effective rainfall from the crop root zone accrued and higher irrigation intensity is required to compensate the crop water needs regardless the soil types. The research findings agree with the report of Bhatt and Hossain (2019) who confirmed that although evapotranspiration (ET) is being affected by a number of factors like soil temperature, soil moisture and vapor pressure gradients, ET remains almost remains similar for a particular soil textural class and agro-climatic conditions and play a crucial role in managing crop water demand.

4. Crop Water Requirement (CWR) of soybean under sprinkler irrigation

In irrigation practice, Crop water requirement is mainly a function of crop evapotranspiration which should be monitored in the mid-stages attributed to more crop water demand owing to full canopy development in addition to evaporative demand. However, in the late stage, though there is not much variation in the atmospheric demand, the transpiration rate decreases due to decrease in physiological activity of plants and other water consumptive use. The determination crop water requirement relies effectively on the effective rainfall and irrigation requirement. The results related to Crop Water Requirement of soy bean were first rely on the estimation of effective and Irrigation requirement from Nasho sector under monitored by Mpanga substation of Rwanda Metrological Agency (RMA). The summary results of Effective rain and Irrigation Requirement from Nasho GFI under soybean production are now shown in table 3 below.

Table 3: Estimation of Crop Water Requirement (CWR) of soybean

Month	Decade	Stage	Kc (coeff)	Etc (mm/day)	Etc (mm/dec)	Eff rain (mm/dec)	Irr. Req. (mm/dec)
May	2	Init	0.35	2.12	12.7	11.7	3
May	3	Init	0.35	2.15	23.7	15.8	7.9
Jun	1	Deve	0.42	2.59	25.9	11.2	14.7
Jun	2	Deve	0.64	4.06	40.6	6.6	34
Jun	3	Deve	0.88	5.46	54.6	6.8	47.8
Jul	1	Mid	1.04	6.4	64	7.2	56.8
Jul	2	Mid	1.05	6.35	63.5	6.7	56.7
Jul	3	Mid	1.05	6.5	71.5	7.6	63.9

Aug	1	Mid	1.05	6.72	67.2	8.4	58.8
Aug	2	Mid	1.05	6.9	69	9	60
Aug	3	Mid	1.05	6.49	71.4	10.4	61
Sep	1	Late	0.96	5.53	55.3	11.4	43.9
Sep	2	Late	0.76	4.11	41.1	12.5	28.5
Sep	3	Late	0.6	2.98	17.9	9.6	9.9
Average					**678.4**	**134.9**	**547**

Source: Author, 2020

The total rainfall and effective rainfall were used to predict the Crop Water Requirement of soy beans under sprinkler irrigation. The physiological stage under study was Mid stage or development stage were needed irrigation. Table 3 shows that the total Crop evapotranspiration of soybean was found to be 678.4mm/dec while effective rainfall need per soybean production was found to be 134.9 mm/dec and the Irrigation water requirement per soybean under sprinkler irrigation system was found to be 547mm/dec. The planting date of soybean was 15 May 2020 and the total duration of growing period was 135 days. The high water consumption by soybean crops was accrued since in mid stage of growing from 34mm/dec to 47.8mm/dec observed in the month of June, 56.7mm/dec to 63.9mm/dec in July and from 58.8mm/dec to 61mm/dec observed in the months of August. At the harvest stage of soybean, the irrigation water requirement dropped down from 43.9mm/dec up to 9.9mm/ dec observed at the end of 26 September 2020.

By nature, Crop water requirement depends on numerous factors including crop evapotranspiration, soil water holding capacity and mainly by soil types. Soil texture and soil structure are both unique properties of the soil that will have a profound effect on the behavior of soils water retention in the root zone. According USDA soil texture triangle, Soil from Nasho irrigation scheme is classified into sandy loam soil which has more infiltration rate and lesser water holding capacity compared to silt and clay soil. Thus the soil from the study area favor higher infiltration and reduce effective rainfall of soybean plant and impacting crop water needs which requires successive irrigation. But, when the soil was set to be clay sandy loam soil, it has to keep higher water holding capacity and diminish irrigation requirement for both the properties influence the crop ET through influencing the water holding capacity of the soils. The findings are consistent with the research done by Aufforth (2018), (Pereira & Pires, 2011) who confirmed that Clay soils are better to have higher water holding capacity than sandy soils and are proficient of preserving a more persistent crop ET rate for longer.

5. Irrigation scheduling of soybean under sprinkler irrigation

Irrigation scheduling is essential for good water management and it deals with two classical questions related to irrigation. These are (1) how much to irrigate and (2) How often to irrigate (irrigation intervals). How often and how to irrigate is function of irrigation water needs of the crop. Generally, drips irrigation systems are designed to meet irrigation water requirement on daily or at an interval of 2-3 days. However, longer gap between irrigations is maintained in other irrigation system. In any case, irrigation interval is chosen such that crop does not suffer from water tress.The CROPWAT 8 computer package was used to work out the irrigation scheduling by keeping the irrigation efficiency of 70%. The effect of irrigation schedule is shown in table 4 below.

Table 4: Irrigation scheduling for soybean production under sprinkler irrigation

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			Mm	fract.	%	%	Mm	Mm	mm	Mm	l/s/ha
15-May	1	Init	0.00	0.60	60	73	28.8	0.00	0.00	41.10	4.75
5-Jun	22	Dev	0.00	1.00	100	50	22.5	0.00	0.00	32.10	0.18
15-Jun	32	Dev	0.00	1.00	100	58	27.3	0.00	0.00	39.10	0.45
22-Jun	39	Dev	0.00	1.00	100	57	27.9	0.00	0.00	39.80	0.66
28-Jun	45	Dev	0.00	1.00	100	58	29.3	0.00	0.00	41.80	0.81
3-Jul	50	Dev	3.70	1.00	100	51	26.4	0.00	0.00	37.70	0.87
8-Jul	55	Mid	0.00	1.00	100	54	28.3	0.00	0.00	40.40	0.94
13-Jul	60	Mid	3.50	1.00	100	55	28.4	0.00	0.00	40.50	0.94
18-Jul	65	Mid	0.00	1.00	100	54	28.3	0.00	0.00	40.40	0.93
23-Jul	70	Mid	3.90	1.00	100	54	28.3	0.00	0.00	40.40	0.93
28-Jul	75	Mid	0.00	1.00	100	55	28.6	0.00	0.00	40.80	0.94
1-Aug	79	Mid	0.00	1.00	100	50	26.2	0.00	0.00	37.40	1.08
6-Aug	84	Mid	0.00	1.00	100	56	29.2	0.00	0.00	41.80	0.97
10-Aug	88	Mid	0.00	1.00	100	52	26.9	0.00	0.00	38.40	1.11
15-Aug	93	Mid	0.00	1.00	100	57	29.8	0.00	0.00	42.60	0.99
20-Aug	98	Mid	0.00	1.00	100	57	29.8	0.00	0.00	42.60	0.99
25-Aug	103	Mid	0.00	1.00	100	52	27	0.00	0.00	38.50	0.89
30-Aug	108	Mid	0.00	1.00	100	52	27	0.00	0.00	38.50	0.89
5-Sep	114	End	0.00	1.00	100	54	28.1	0.00	0.00	40.20	0.77
11-Sep	120	End	0.00	1.00	100	50	26.2	0.00	0.00	37.50	0.72
20-Sep	129	End	0.00	1.00	100	50	26.2	0.00	0.00	37.50	0.48
26-Sep	End	End	0.00	1.00	0	17	5	-	-	-	-
Total Irrigation requirement (15/5 -26 /09/2020)							***580.5***			***829.1***	***21.29***

Irrigation Scheduling	**Quantity**	**Rainfall parameters**	**Quantity**
Total Gross Irrigation	829.0 mm	Total rainfall	138.4mm
Total Net Irrigation	580.3mm	Effective rainfall	121.7mm
Total Irrigation Losses	0.00mm	Total rain loss	16.8mm
Actual water use by crop	674.5mm	Moist deficit at harvest	8.9mm
Potential water by crop	675.4mm	Actual Irrigation requirement	553.7mm
Efficiency Irrigation schedule	100%	Efficiency Rain	87.9%
Deficiency Irrigation schedule	0.1%	-	-

Author, 2020

Based on the results generated from CROPWAT 8 computer package, table 4 brings out the irrigation schedule by indicating the dates and corresponding gross and net irrigation. The planting of soybean started on 15 May of the year and the harvesting date was scheduled on 26 September and the total duration of the crop was 135 days. There were three stages of the crop management namely initial stage, development stage (mid stage) and harvesting (end) stage. The water stress coefficient (Ks) was assumed varied from 0.6 to 1 and the actual evapotranspiration (ETa) was assumed as 100% during the entire cropping season.

The moisture depletion pattern during the irrigation schedule varies from 50% to 73% with an average depletion of 17% for the whole cropping period. The net irrigation supplied to the field varies from 22.5 mm to 29.8 mm with an average net irrigation requirement 5 mm. The total net irrigation supplied to the field was 580.3 mm. It was found that the deficiency irrigation was 0.1% due to wind on the sprinklers and crops and hence it was marked as 0.1% during the entire cropping schedule of May to September. The gross irrigation water requirement was varying from 32.1 mm to 42.6mm with an average total gross irrigation requirement of 829.1 mm. The Gross Irrigation requirement was found to be 829.0 mm which makes 0.1% of water deficit. During the irrigation scheduling, the total average flow rate of water to the field was computed and was found to be to be 21.29 liter/sec/ha while during growing period, it was ranging from 0.11 liter/sec/ha to 4.75 liter/sec/ha respectively. Similarly, total rainfall during the season was 138.4 mm and the effective rainfall during the season of May to September was 121.7 mm. The total rain loss accrued in the field was found 16.8mm. The computed moisture deficit at the harvesting stage was 8.9 mm. The study findings also showed that the actual irrigation requirement was found to be 553.7 mm while the irrigation efficiency of the modeling was 100% and the efficiency of rain was 87.9%. The irrigation schedule is paramount factor to determine the salts accumulation and the quality attributes of the crops. Soybean subjected with higher intensity of water load extracted more water in the continuous irrigation schedule, whereas the same crop with controlled water load extracted regulated water in schedules with irrigation cutback before harvest. The interaction between increased irrigation quantity and frequency with either extremely high or low crop load resulted in delayed salts accumulation and thus improper crop growth. Delayed ripening also could be a negative effect associated with uncontrolled irrigation schedule and thus low soy bean production. The findings are consistent with the research conducted by Bravdo *et al.* (1985) who found that low wine quality only in the most intensive irrigation schedule is tending to give the lowest wine production and quality.

V. Conclusion and Recommendations

It was found that the mean ETo from Nasho farm under soybean farming was found to be 4.79 mm/day. Its range varies from 2.77 mm/day to 6.47 mm/day and was found that maximum ETo was found in the month of August while the minimum was found in the month of December. The difference between maximum and minimum of ETo was found to be 3.7 mm/day. It is concluded that the fact that there is a high difference mean in solar radiation leads to the effect of high evapotranspiration rate of soy bean which reflect high water needs for irrigation in the sunny period. For Crop Water Requirement, it was found that also the total of rain fall was found to be 785.2mm while the effective rain fall was found to be 678.8mm for the period of twelve months. It is concluded that that total amount of water stored in soybean root zone is less than the total water needed by soy beans and therefore the crop can't suffer from water deficit.

For irrigation scheduling, the total Crop evapotranspiration of soybean was found to be 678.4mm/dec while effective rainfall need per soybean production was found to be 134.9 mm/dec and the Irrigation water requirement per soybean under sprinkler irrigation system was found to be 547mm/dec. It is also recommended that different riser heights may also be studied to observe their effect on the measures of sprinkler irrigation system performance, to cater for the cultivation of other crops. Based on findings, remarks envisaged that Irrigation practice should be performed during morning time which is better due to low temperature, low wind speed and high relative humidity availability.

VI. Acknowledgment

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VII. References

[1] Allen, R. G., L. S. Pereira, D. Raes and M. Smith, 1998: FAO Irrigation and drainage paper No. 56. *Rome: Food and Agriculture Organization of the United Nations,* **56,** e156.

[2] Aufforth, M. E., 2018: Uncertainty and Model Sensitivity of Agriculture Irrigation on Atmospheric Latent Heating. University of Wisconsin--Madison.

[3] Bhatt, R. and A. Hossain, 2019: Concept and consequence of evapotranspiration for sustainable crop production in the Era of climate change. *Advanced Evapotranspiration Methods and Applications.* IntechOpen.

[4] Bravdo, B., Y. Hepner, C. Loinger, S. Cohen and H. Tabacman, 1985: Effect of irrigation and crop level on growth, yield and wine quality of Cabernet Sauvignon. *American Journal of Enology and Viticulture,* **36,** 132-139.

[5] Dinar, A. and J. Mody, Irrigation water management policies: allocation and pricing principles and implementation experience. in Proceedings of the Natural Resources Forum, 2004, p. 112-122.

[6] Djaman, K., A. B. Balde, A. Sow, B. Muller, S. Irmak, M. K. N'Diaye, B. Manneh, Y. D. Moukoumbi, K. Futakuchi and K. Saito, 2015: Evaluation of sixteen reference evapotranspiration methods under sahelian conditions in the Senegal River Valley. *Journal of Hydrology: regional studies,* **3,** 139-159.

[7] Djaman, K., V. C. Mel, B. V. Bado, B. Manneh, L. Diop, D. Mutiibwa, D. R. Rudnick, S. Irmak and K. Futakuchi, 2017: Evapotranspiration, irrigation water requirement, and water productivity of rice (Oryza sativa L.) in the Sahelian environment. *Paddy and Water Environment,* **15,** 469-482.

[8] Habineza, E., J. N. Nsengiyumva, E. Ruzigamanzi and M. V. Nsanzumukiza, 2020: Profitability Analysis of Small Scale Irrigation Technology Adoption to Farmers in Nasho Sector, Rwanda. *Journal of Agricultural Chemistry and Environment,* **9,** 73.

[9] Hamdy, A., R. Ragab and E. Scarascia-Mugnozza, 2003: Coping with water scarcity: water saving and increasing water productivity. *Irrigation and Drainage: The Journal of the International Commission on Irrigation and Drainage,* **52,** 3-20.

[10] Jensen, M., 1968: Water consumption by agricultural plants. Chap. 1 in Water Deficits and Plant Growth. Vol. II, TT Kozlowski, ed. Academic Press, New York.

[11] Jensen, M. E., R. D. Burman and R. G. Allen, Evapotranspiration and irrigation water requirements. in, 1990.

[12] Keller, J. and R. D. Bliesner, 1990: Sprinkle and trickle irrigation.

[13] Pereira, A. and L. Pires, 2011: Evapotranspiration and water management for crop production. *Evapotranspiration-From Measurements to Agricultural and Environmental Applications.* IntechOpen.

[14] Pereira, L. S., R. G. Allen, M. Smith and D. Raes, 2015: Crop evapotranspiration estimation with FAO56: Past and future. *Agricultural Water Management,* **147,** 4-20.

[15] Sentelhas, P. C., T. J. Gillespie and E. A. Santos, 2010: Evaluation of FAO Penman–Monteith and alternative methods for estimating reference evapotranspiration with missing data in Southern Ontario, Canada. *Agricultural Water Management,* **97,** 635-644.

[16] Yoshida, Y., H. Tanji, H. Somura, O. Toda and K. Higuchi, Evaluation of irrigation efficiency at KM6 project site, Laos. in Proceedings of the Proceeding of the 2nd APHW Conference, Singapore, 2003, p. 652-659.