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Evaluation of Irrigation Scheduling for Sprinkler Irrigation System under Existing Condition in Beles Sugar Development Project, Ethiopia

Fikadu Kinfe Abshiro[1]* and Pratap Singh[2]

[1]*Sugar Corporation Research and Development Center, Wonji, Ethiopia*
[2]*Arbaminch University Institute of Technology, Ethiopia*

Abstract

Appling appropriate field irrigation practices safeguard that crops could get peak supply of water in their root zone for achieving best yield of crops without facing water stress and damaging the quality of soils. Sugar cane fields at study area irrigated to irrespective of the soil type, growing month, and stage of crop growth with the design application efficiency of 70%. Currently the system was not working with the full design capacity so that evaluating the irrigation scheduling under existing condition was very important. Therefore, this study was conducted to evaluate irrigation scheduling with design standards, and develop irrigation scheduling based on the actual existing water application with respect of soil, growing month and stage of growth. Representative soil samples were taken for soil texture, bulk density, field capacity and wilt point test. Secondary data collected were weather data, effective root depth and crop coefficient. The performance parameters analyzed were, crop evapotranspiration, net irrigation requirement, net depth of application, irrigation interval, sprinkler set hour, and application efficiency. The average sprinkler discharge at 3.0 and 2.5 bar operating pressure was 0.9 and 0.8 m3/h respectively. The sprinklers had an average actual application efficiency of 62%. Sprinkler set hours obtained for the age of 0-3, 3-6, 6-15 and >15 month was 13, 19, 25 and 38 h respectively. Irrigation interval obtained for age of 0-3, 3-6, 6-15 and >15 month varied with growing month and had a range of 7-10, 6-21, 7-20, and 16-24 days respectively. According to the study the system was not working under full design capacity. The irrigation scheduling based on the system actual working condition was recommended with respect of growing month and stage of growth.

Keywords: Irrigation scheduling; Sprinkler set hour; Irrigation interval; Soil; Growth stage; Growing month; Sprinkler discharge

Introduction

The purpose of irrigation scheduling is to determine the exact amount of water to apply to the field and the exact timing for application. The amount of water applied is determined by using a criterion to determine irrigation need and a strategy to prescribe how much water to apply in any situation [1]. Water deficit in sugarcane limits growing and maturity of tissues, reduces nitrogen uptake and utilization, and increases thickness of cell wall. It is observed that sugarcane under moisture stress shows higher brix and purity much earlier and maintains it for a longer period though tonnage is lower than the crop receiving no stress [2,3]. On the other hand, water logging causes a higher rate of mortality, retarded growth, and poor juice quality.

The use of applicable field irrigation practices safeguard that plants could get peak supply of water in their root zone for achieving optimum yield of crops without damaging the quality of soils. Therefore, this is achieved by knowing the interaction among soil, plant and water. The basic problem concerning efficient use of water for agriculture is to apply correct amount of water uniformly with minimum loss. It is important that correct amount of water should be applied as needed by the crop so that the crops best grow to give maximum yield [3].

Beles Sugar Development Project has started seed and commercial cane plantation work in 2012 year using gravity flexible hose move sprinkler irrigation. Currently the plantation cane field covers around 12000 ha of land. Having this, the project was faced with problem of appropriate filed irrigation water application (which is applying water at uniform level with irrespective of the soil, growth stage, and climate. As field measurement and evaluation undertaken the system was working below the designed capacity. Thus, irrigation scheduling undertaken by the project was not suitable with the current working condition of the sprinkler irrigation system installed. So far there was no study done in this area concerning about stated irrigation scheduling gaps.

Therefore, the objective of this study was to evaluate and recommend appropriate irrigation scheduling of the sprinkler irrigation system under existing working condition.

Materials and Methods

Description of the study area

The study was conducted at Tana Beles Integrated Sugar Development Project which is located near Fandica Town, capital of Jawi Woreda, which is found in the western periphery of Amhara National Regional State, 149 and 70 km from Bahir Dar and Dangela towns, respectively. The study area has low to medium relief differences with an altitude range of 806 to 1242 meters above sea level.

The project area is characterized as warm humid climate with mean annual humidity reaching to 80% and the maximum temperature fluctuating between 37°C in April and 27C in July, while the minimum temperature variation is bounded between 12°C and 19°C. Over all, the project area is considered to be humid with relative humidity ranging between 66 and 92% [4]. The mean annual rainfall around the irrigation scheme is represented by Pawi Station with mean annual rainfall of 1576 mm (from 1986-2006) [4]. The 44.4% of irrigation command area has a gently slope range from (2-5%). Verti sols cover more than 50% of the command area among the five categories of soil types [4].

***Corresponding author:** Fikadu Kinfe Abshiro, Sugar Corporation Research and Development Center, Wonji, Ethiopia, Tel: +251-(0)11-552-6653/552-6896; E-mail: kinfe.fikadu1@gmail.com

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Assessment of the existing sprinkler irrigation practice

Assessment of current sprinkler irrigation practice was done by referring the feasibility and design study document, field observation, field report and by physical contact with Technical responsible Staffs such as Irrigation, and Plantation Staff. The assessment contained: i) frequency of irrigation, ii) irrigation setting hour per day, iii) application of water with respect to soil, growing month and growth stage and sprinkler water application efficiency.

Materials used

The materials used to collect the primary data were Auger hole, core sampler, soil plastic pack, tag number, stopwatch, tape meter, water bucket container, plastic water hose (4 m) used to measure nozzle discharge, hammer, and other related accessory materials

Soil data

A total of 44 representative soil samples at a depth of 0-30 and 30-60 cm were taken randomly at TM3 and TM2 fields using auger hole and core samplers. Currently these selected fields are covered with cane and the samples were considered the lowest, medium and highest spot of the fields, and the sample depths were considered the average root depth concentration of 60 cm. The samples were tested for soil texture, bulk density, field capacity, and permanent wilting point. The soil texture (percentage of sand, silt and clay) and bulk density were tested at Pawi Research Center laboratory. Field capacity and permanent wilting point were tested using pressure plate membrane at Amhara Design and Supervision Works Enterprise, Soil Chemistry and Water Quality Section Laboratory, Bahir Dar, Ethiopia.

Crop root depth and crop coefficient

According to survey data made at Fincha and Metahara Sugar Estates by Habib [3] and Solomon [5], the root depth and crop coefficient values for sugar cane at different growth stages were summarized below:

In Ethiopian Sugar Estates similar cane varieties are grown, and cane management practices have been done. The study area soil has similarity with Fincha Sugar Estates. Thus, in this study also the same root depth and crop coefficient values with respect of their growing stages were used. Tate [6] recommended, considering top 60 cm as an effective rooting depth was appropriate to estimate soil moisture deficit for irrigation timing of sugarcane. This was to protect the crop from moistures stress in its effective root area (Table 1).

Climatic data used

The climatic data collected for Pawi Metrology Station. It is located at a geographical location of 36.4 degree longitude, 11.3 degree latitude, and 1119 m above mean see level. The data used were 16 year rainfall, 10 year maximum temperature, 16 year minimum temperature, 15 year sunshine hour, 10 year relative humidity, 5 year wind speed.

Cane age (months)	Root depth (cm)	Crop coefficient
0-3	30	0.55
3-6	45	0.9
6-15	60	1.05
Above 15	90	0.7

Source: (Habib, 2001 and Solomon, 2010).

Table 1: Root depth and Crop coefficient at different cane ages.

Performance parameters

The following parameters were analyzed to evaluate the sprinkler irrigation system installed at Beles Sugar Development Project

Net depth of water application (dn): Net depth of irrigation water applied for the study area was estimated using the formula:

$$dn = TAW * P * Dr * \rho i \quad (1)$$

Where, TAW=Total available water for the soil sample (%) TAW=(FC–PWP)*;

FC-moisture content of the soil at filed capacity (%);

PWP-moisture content of the soil at permanent wilting point (%);

ρi-the soil bulk density (1 g/cm^3);

Dr-maximum effective root depth (m) differs for different growth stage;

P-moisture depletion factor.

Previous studies of Habib [3] and Solomon [5] the optimum factor of depletions used in their studies for sugarcane was in between 0.50 to 0.65 which was also proposed by Tate [6] for Metahara Sugar Estate soils, and was in agreement with recommended 0.55 by Rao [7] and 0.65 by FAO [8]. Considering 90% concentration of effective rooting depth at top 60 cm was appropriate to estimate soil moisture deficit for irrigation timing of sugarcane Tate [6]. This was to protect the crop from moistures stress in its effective root area. Thus, 60% soil moisture depletion factor was used for this study.

Gross depth of water application (dg): The gross depth of irrigation water applied of the study area was estimated using eqn. (2) according to Merriam and Keller [9]:

$$\text{Gross depth of water application (mm)} = \frac{\text{net depth of water application (mm)}}{\text{sprinkler actual applcation efficiency}} \quad (2)$$

Estimation of the crop water requirement: The Crop water requirement (ETc) of the study area was determined by multiplying reference evapotranspiration of the crop with corresponding crop coefficient (Kc) for each month and stage of growth

$$\text{ETc (mm/day)} = \text{ETO} * \text{Kc} \quad (3)$$

Where,

ETO-the crop reference evapotranspiration, which was estimated based on FAO Penman-Monteith method equation [10] by using FAO CROPWAT 8 software.

The data input used for the software were stated in 2.6.

Kc-Crop coefficient; the Kc value used for this study was varying with initial stage (0-3 months), development stage (3-6 months), mid-season stage (6-15 months), and late season stage (>15 months). Tate [6] and Habib [3].

Effective rainfall (mm): The effective rainfall of the study area was estimated using FAO CROPWAT8 Software, USDA Soil Conservation Service method. The rainfall data input used for the software for effective rainfall output was 80% dependable rainfall which is derived from 16 year monthly rainfall data.

Net irrigation water requirement: The actual net irrigation water requirement of the study area was estimated using the method outlined by Habib [3] for each month.

$$NIR = ETc - Pe - Gw \quad (4)$$

Where,

NIR=net irrigation water requirement of the crop;

Pe-effective rainfall and

Gw-ground water contribution.

However, the effect of ground water contribution was assuming zero as per some field observations taken and there was no water at 1.5 m from the surface. These observations were observed in dry seasons. Actually there is no irrigation at wet seasons especially from June to September because the effective rainfall is enough to meet the crop water requirement. Thus, study of the ground water contribution in wet seasons is not necessary for irrigation requirement unless for drainage.

Irrigation interval (I): The actual irrigation interval of the study area was determined for each month, growth stages, and soil type using eqn. (5):

$$I\left(days\right) = \frac{net\ depth\ of\ application\left(mm\right)}{crop\ water\ water\ requirment\left(\frac{mm}{day}\right)} \quad (5)$$

To consider the wet seasons which have enough effective rainfall to meet the crop water requirement and to avoid over water application, the net irrigation water requirement was used in terms of crop water requirement (ETC) to estimate the irrigation interval of the study area.

Sprinkler set time (T): The sprinkler set time is the specified time duration to apply the required depth of water for set of sprinkler. It is represented by hours per day. The actual sprinkler set time for the study area was determined using eqn. (6):

$$T = \frac{dg}{Ig} \quad (6)$$

Where,

dg-gross depth of water application (cm);

Ig-gross sprinkler water application rate (cm/h);

Ig was estimated using the eqn. (7):

$$Ig = \frac{q * 360}{Sm * Sl} \quad (7)$$

Where,

q-the actual sprinkler discharge (lit/sec);

Sm-lateral spacing (m);

Sl-sprinkler spacing (m).

For this study the existing spacing 18*18 m was used.

Result and Discussion

Assessment of the sprinkler irrigation system design and water application practice

According to TBISDP [10,11] the sprinkler irrigation system is designed to nozzle discharge of 1.8 m^3/h at a nozzle operating pressure of 3.1 bar and hydrant valve operating pressure of 4.0 bar. But now, most of fields are working below these design operating pressures that mean the actual discharge is below the design capacity. Having this, most of sugar cane fields were under water stress. The laterals were designed with actual spacing of 90 m, but in some fields it is more or less than this value. The sprinklers were designed with spacing of 18*18 m, but in some fields the existing spacing in practice was less or more than this value. Also hydraulic valves between laterals are not parallel each other. Finally these cause non uniformity of water application in most fields. Thus, the project better to takes remedial measurement accordingly.

The project practices 24 sprinkler set hour and 15 days irrigation interval according to Feasibility and Design Study document [4]. The existing water application was not considered the soil type, growth stage, and growing month. Also the system was not working as per design capacity. Due to these, under water applications in most of fields were found and caused poor cane growth and performance which intern reduced the expected yield per hectare. Therefore, rescheduling the irrigation system at existing condition is very important.

Performance parameters analysis

The following parameters were discussed to evaluate irrigation scheduling under existing working of the sprinkler irrigation system installed at Beles Sugar Development Project.

Reference crop evapotranspiration (ETo): Reference evapotranspiration estimated for the study area for each months of year using CROPWAT 8.0 model and estimated values are given in Table 2.

According to Table 2, long term average maximum temperatures for the study area was highest from March through to April, with lows in August and July when clouds persists through the wet season. A maximum monthly temperature of 37.7°C occurred in March with a low of 27.9°C in August. The humidity was highest in September and August in the wet season when humidity reached 91 and 90%, respectively, and a minimum of 63 and 67% occurred in April and

Months	Min Temp ˚C	Max Temp ˚C	Humidity %	Wind km/day	Sunshine hours	ETo mm/day
Jan	13.7	33.7	72	42	9.7	3.98
Feb	16.7	35.6	66	50	9.5	4.51
Mar	19.2	37.7	67	57	9.1	5.09
Apr	20.8	37.5	63	63	9.4	5.46
May	20.5	34.4	77	72	8.3	4.94
Jun	19.3	30.9	85	64	6.8	4.12
Jul	18.9	28.2	87	54	5.0	3.45
Aug	18.6	27.9	90	52	5.0	3.42
Sep	18.2	29.0	91	43	6.4	3.75
Oct	17.9	30.5	88	35	8.0	4.00
Nov	15.3	32.2	84	34	9.4	4.01
Dec	13.5	33	80	41	9.7	3.87

Table 2: Reference evapotranspiration for each month of the study area.

March respectively in the dry season. Thus, the highest ETo was in March and April respectively whereas the lowest minimum ETo was in August [12].

Crop water requirement (ET_C): The cane water requirement estimated for the study area for each growing months and growth stages using eqn. (3) were given in Table 3.

According to Table 3, the maximum cane water requirement was 5.73 and 5.34 mm/day in the months of April and March respectively in the growth stage of 6-15 months. This is due to, the highest evapotranspiration in these months and the highest crop coefficient in the growth stages of 6-15 months. The minimum cane water requirement is 1.88 and 1.90 mm/day in the months of August and July, respectively in the growth stage of 0-3 months. This is due to, the minimum evapotranspiration in these months and the lowest crop coefficient in the growth stages of 0-3 months.

Effective rainfall (Pe): The effective rainfall estimated for the study area for each month using CROPWAT 8.0 model, USDA Soil Conservation Service method for the 80% dependable rainfall was given in Table 4.

According to Table 4, average monthly effective rainfall exceeds crop water requirement in the wet season from June to September, indicating that, the average monthly rainfall in this wet season can fulfill more than the need of crop requirement and no need of irrigation. Thus, surface drainage is needed to remove the excess water from the field, especially in water logged fields. Other than, these wet seasons irrigation water is needed to meet the crop requirement. Thus, the study supports the design document that no need of irrigation water in wet seasons from June to September.

Net irrigation water requirement (NIR): The net irrigation water requirement estimated for the study area for each growing months and growth stages using eqn. (4) are given in Table 5.

Net depth of water application (dn): The soil physical parameters of the study area tested in soil laboratory were given in Table 6. Based on result Table 6, the soil textural type selected for evaluation was namely clay type which was categorized under vertisols. Vertisols covers more than 50% of the Project command area. The bulk density values less than 1.0 g/cm^3 in the above table shows that the actual field soils were red clay soils and they have consideration percent of silt and sand compared to the black clay soil bulk density values which have greater than 1.0 g/cm^3. Most of these red clay soils are found at highest elevation compared to the black clay soils. The soil total available water (TAW) ranges from 6.19% to 14.38%, the black clay soils take the highest values.

The net depth of application is increasing with respective increasing of age and effective root depth. According to this table the net depth of application was vary from age to age, which are range from 20.99 mm to 62.96 mm (Table 7).

Irrigation interval (I): The irrigation interval estimated for clay textural type (vertisols) of the study area using eqn. (5) for each growing months and growth stages were given in Table 8. As shown in the Table 8, the irrigation interval varied from month to month for the same growing age due to the monthly climatic variations, and also it

Growing month/ cane age	ET_c, mm/d			
	0-3 month	3-6 month	6-15 month	>15 month
Jan	2.19	3.58	4.18	2.79
Feb	2.48	4.06	4.74	3.16
Mar	2.80	4.58	5.34	3.56
Apr	3.00	4.91	5.73	3.82
May	2.72	4.45	5.19	3.46
Jun	2.27	3.71	4.33	2.88
Jul	1.90	3.11	3.62	2.42
Aug	1.88	3.08	3.59	2.39
Sep	2.06	3.38	3.94	2.63
Oct	2.20	3.60	4.20	2.80
Nov	2.21	3.61	4.21	2.81
Dec	2.13	3.48	4.06	2.71

Table 3: The cane water requirement for each growing month and growth stages of the study area.

Month	80% dependable rainfall (mm)	Effective rainfall (mm per month)	Effective rainfall (mm per day)
Jan	0	0.00	0.00
Feb	0	0.00	0.00
Mar	0	0.00	0.00
Apr	0.1	0.10	0.00
May	28.6	27.30	0.88
Jun	208.7	139.00	4.63
Jul	239.2	147.70	4.76
Aug	319.4	156.90	5.06
Sep	204	137.40	4.58
Oct	73.4	64.80	2.09
Nov	2	2.00	0.07
Dec	0	0.00	0.00
Total	1075.4	675.20	22.08

Table 4: Effective rainfall for each month of the study area.

Growing month/ cane age	NIR, mm/d			
	0-3 month	3-6 month	6-15 month	>15 month
Jan	2.19	3.58	4.18	2.79
Feb	2.48	4.06	4.74	3.16
Mar	2.80	4.58	5.34	3.56
Apr	3.00	4.91	5.73	3.82
May	1.84	3.57	4.31	2.58
Jun	*	*	*	*
Jul	*	*	*	*
Aug	*	*	*	*
Sep	*	*	*	*
Oct	0.11	1.51	2.11	0.71
Nov	2.14	3.54	4.14	2.74
Dec	2.13	3.48	4.06	2.71

The asterisk sign (*) shows that there is no need of irrigation water in wet seasons from June to September, indicating that the average monthly effective rainfall of these wet seasons is more than enough to fulfill the need of the crop water requirement. In contrary, the full irrigation water is needed in dry seasons from January to April and from November to December.

Table 5: The net irrigation water requirement for each growing month and growth stages.

S/N	Field Number	Parameters (FC and PWP						Bulk density (gm/cm³)	Texture type	TAW(%)
		FC%			PWP(%)					
		Soil sample depth (cm)		Average	Soil Sample depth (cm)		Average			
		0-30	30-60		0-30	30-60				
1	TM3-20-1	32.24	31.41	31.83	18.56	23.61	21.09	1.14	Clay	10.74
2	TM3-22/23-2	31.44	31.96	31.70	23.72	25.08	24.40	0.9.	Clay	7.30
3	TM3-22"R1	48.77	48.92	48.85	34.02	34.91	34.47	1.06	Clay	14.38
4	Tm2-N1	29.07	29.24	29.16	22.89	23.05	22.97	0.91	Clay	6.19
5	Tm2-20"	41.52	41.24	41.38	28.16	29.1	28.63	1.22	Clay	12.75
6	Tm2-ext	34.07	40.01	37.04	23.21	26.42	24.82	1.24	Clay	12.23
Average								1.1		10.60

The net depth of water application (dn) estimated for the clay soil textural type (vertisols) of the study area using equation 1 for each growth stage.

Table 6: Soil parameters FC, PWP, soil textural type, and bulk density for each field of study area.

Parameters/growth month	Growth age in month			
	0 - 3	3 - 6	6 - 15	>15
Effective root depth(Dr), in cm	30	45	60	90
Moisture depletion factor (p) in %	60	60	60	60
Total available water in %	10.6	10.6	10.6	10.6
Soil bulk density (Bdi) in g/cm³	1.1	1.1	1.1	1.1
Net depth of application(dn) in mm	20.99	31.48	41.98	62.96

Table 7: Net depth of water application for each cane growth age of the study area.

varied from age to age for the same growing month due to variation of crop coefficient and effective root depth across different age. Currently 15 days irrigation interval is used without consideration of cane growth stage, growing month and soil type. According to this study the irrigation interval varied with respect of growing month and stage of growth as shown in the table.

As practical field experience and the crop age of behavior, the first growth stage (0-3 month) of irrigation interval should be reasonable to take as a week interval because the cane crop needs considerable amount of water frequently at its initial growth stage. It needs to check soil moisture status with nearby apparatus such as, augur test and others soil moisture sensors. For the rest of growth stages irrigation intervals have to be applying according to its growing month and growth age of the crop as the stated irrigation interval in Table 8.

Sprinkler set hour and gross depth of application: The sprinkler set hour and gross depth of application estimated for the clay textural type (verti sols) of the study area using eqns. (6) and (2) respectively for each stage of growth and growing month under existing sprinkler operating condition were given in Table 9 [13].

Currently the project followed 24 irrigation set hour irrespective of cane stage of growth and the soil. There is no information which shows weather the soil physical properties of the project area are considered or not. The sprinkler is set to work for 24 hour with a design capacity hydrant pressure of 4.0 bar, sprinkler discharge of 1.8 m³/h and design application efficiency of 70%. According to this study the actual average sprinkler discharge obtained was 0.9 and 0.8 m³/h at a hydrant pressure of 3.0 and 2.5 bar, respectively. Thus, the average actual sprinkler application efficiency by considering the different age of growth and the physical soil properties was 62%. Therefore, the above shown set hour was developed with considering application efficiency of 62% [14].

Conclusions and Recommendations

Conclusions

Evaluation of Beles sprinkler irrigation systems has great

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Growing month/ cane age	Irrigation Interval(I) in days			
	0-3 month	3-6 month	6-15 month	>15 month
Jan	10	9	10	23
Feb	8	8	9	20
Mar	7	7	8	18
Apr	7	6	7	16
May	11	9	10	24
Jun	*	*	*	*
Jul	*	*	*	*
Aug	*	*	*	*
Sep	*	*	*	*
Oct	*	21	20	*
Nov	10	9	10	23
Dec	10	9	10	23

The asterisk sign (*) shows that no need of irrigation as stated in above irrigation interval table.

Table 8: Irrigation interval for each growing month and growth stages of the study area.

Month	Gross depth of application dg, mm				Sprinkler set hours (T)			
	Stage of growth				Stage of growth			
	0-3	3-6	6-15	>15	0-3	3-6	6-15	>15
Jan	33.85	50.78	67.70	101.55	13	19	25	38
Feb	33.85	50.78	67.70	101.55	13	19	25	38
Mar	33.85	50.78	67.70	101.55	13	19	25	38
Apr	33.85	50.78	67.70	101.55	13	19	25	38
May	33.85	50.78	67.70	101.55	13	19	25	38
Jun	*	*	*	*	*	*	*	*
Jul	*	*	*	*	*	*	*	*
Aug	*	*	*	*	*	*	*	*
Sep	*	*	*	*	*	*	*	*
Oct	33.85	50.78	67.70	101.55	13	19	25	38
Nov	33.85	50.78	67.70	101.55	13	19	25	38
Dec	33.85	50.78	67.70	101.55	13	19	25	38

The asterisk sign (*) shows that no need of irrigation as stated in above irrigation interval table.

Table 9: The sprinkler set hour and gross depth of application of the study area.

importance. The project practices 24 sprinkler set hour and 15 days irrigation interval. The current sprinkler irrigation scheduling of the sugar project undertaking was not suitable with the current actual water application. Also it is not considered the soil, growing month, stage of growth, and the existing actual application efficiency. As a result, under watering was obtained in most fields, so that the cane performance was low as per this application. Thus, improved irrigation scheduling with respect to the soil, growing month, stage of growth, and the existing actual water application efficiency is very important.

The sprinkler irrigation system is designed to nozzle discharge of 1.8 m^3/h at a nozzle operating pressure of 3.1 bar and hydrant valve operating pressure of 4.0 bar. But now, most of fields are working below these design operating pressures that mean the actual discharge is below the design capacity. Having this, most of sugar cane fields were under water stress. The laterals were designed with actual spacing of 90 m, but in some fields it is more or less than this value. The sprinklers were designed with spacing of 18*18 m, but in some fields the existing spacing in practice was less or more than this value. Also hydraulic valves between laterals are not parallel each other. Finally these cause non uniformity of water application in most fields. Thus, the project better to takes remedial measurement accordingly.

The determined irrigation interval of clay (verti soil) obtained for the age of 0-3, 3-6, 6-15 and >15 month was vary with their growing month and had a range of 7-10, 6-21, 7-20, and 16-24 days, respectively. Sprinkler set hour obtained for the age of 0-3, 3-6, 6-15 and >15 month was 13, 19, 25 and 38, respectively. Currently the project is implementing an irrigation interval and sprinkler set hour of 15 days and 24 hour respectively for all soil type, growing month and stage of growth. According to this study the determined irrigation interval and set hour of is vary with respect of growing month and stage of growth. The developed scheduling was considered the actual determined sprinkler application efficiency. This showed that the irrigation scheduling currently followed has to be improved based on the growing month, stage of growth and its actual water application.

Recommendations

Based on the assessment done and the study result evaluation, the following recommendations were forwarded:

1. As per the currently sprinkler actual application at a hydrant pressure of 2.5 and 3.0 bar, it is better to follow irrigation interval and sprinkler set hour obtained at this study result based on the growing month, and stage of growth as per Tables 7 and 8, respectively for clay (verti soil).
2. The project has to be award that the sprinkler infield irrigation system is working below the design capacity. The lateral spacing 90 m and sprinkler spacing 18*18 m in some fields were not within the design specification.
3. The hydrant pressure gauge and pressure gauge with pitot tube

must be available in numbers to check the daily lateral hydrant and nozzle operating pressure. Also the project has to construct irrigation work shop to take fast and ease service, care and maintenance of the system.

4. The whole irrigation scheme performance from the head work has to be studied. The infield sprinkler irrigation system has to be further studied when the system is working with the full designed capacity of 4.0 bar at hydraulic vale operating pressure.

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