# Real-time irrigation scheduling for upland crop based on soil and climatecharacteristics of tidal lowland area in South Sumatera

*by* Momon Sodik Imanudin

---

**Submission date:** 27-May-2021 08:53AM (UTC+0700)
**Submission ID:** 1594948048
**File name:** Makalah001-2021-Rill_Time_Irrigation.pdf (574.67K)
**Word count:** 5587
**Character count:** 28312

IOP Conference Series: Earth and Environmental Science

# Real-time irrigation scheduling for upland crop based on soil and climate characteristics of tidal lowland area in South Sumatera

To cite this article: M S Imanudin *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **622** 012051

ISCEE 2020 IOP Publishing
IOP Conf. Series: Earth and Environmental Science **622** (2021) 012051 doi:10.1088/1755-1315/622/1/012051

# Real-time irrigation scheduling for upland crop based on soil and climate characteristics of tidal lowland area in South Sumatera

**M S Imanudin[1*], S J Priatna[1], B M B Prayitno[1], and C Arif[2]**

[1]Department of Soil Science, Sriwijaya University, Indralaya South Sumatra, Indonesia 30138
[2]Department of Civil and Environmental Engineering, IPB University, Bogor, Indonesia 16680

E-mail: momonsodikimanudin@fp.unsri.ac.id

**Abstract.** The research aims to determine the water requirement of plants based on soil and climate characteristics in the lowland area of South Sumatra. The study was conducted at the Soil Physics Laboratory, Soil Department, Faculty of Agriculture, Sriwijaya University. Soil samples were taken from lowland areas at Tidal Lowland Reclamation in Telang I Banyuasin. Field research was conducted from March to November 2019. Climatic data were differentiated into rainfall conditions below 2,500 mm/year and more than 2,500 mm/year. The BUDGET model was used for simulations to determine real-time irrigation scheduling. The indicator crop is tomatoes, with a scenario arranged at the dry season planting period. The results showed that in the condition of annual rainfall < 2,500 mm, farmers need more irrigation frequencies compared to rainfall > 2,500 mm. Irrigation is not required under normal climatic conditions. Farmers only need to maintain the groundwater table under 40 cm using gate operation in the tertiary canal. Rainfall was sufficient to fulfill crop evapotranspiration. However, the irrigation scheduling was done every week during the initial growing stage and every ten days in the vegetative up to generative stages in the dry climatic condition.

## 1. Introduction

The plant requires water for its growth and development. The plant continuously needs water, but water availability in terms of quantity, place, and time is not always available. This condition especially occurs during the dry season resulting in a decrease in farming enterprise. Irrigation effort is needed to maintain soil moisture in order to meet crop evapotransporation. Therefore farmer can carry out the cultivation of cropp during dry season.

Agricultural cultivation effort at tidal lowland reclamation area during the wet season is prioritized for rice crops. Therefore, the planting pattern consists of rice-rice. An effort to increase the planting index to 300 % is made by adding vegetable crops or second crops in the third planting season (MT3). The primary constraint at the MT3 period is water deficiency for crops [1]. Thus, a water management plan is required by considering water resource potential, water quality, and water application method. Water management strategy should include how much water to be applied, where it is applied, and priority during the dry season [2]. The capillary water movement is the main water source to fulfill crop evaporation requirement at wetland because water supply for crops can be fulfilled by capillary water movement from the groundwater table 40 cm below the soil surface [3]. Kadioglu et al. [4] had reported that the contribution of shallow groundwater table at loam soil within a depth of 30, 60, and 90 cm to supply crop water requirement was 97%, 71%, and 68%, respectively. Therefore, irrigation scheduling at the swamp area is closely related to groundwater table status in addition to rainfall.

Information related to water application consisting of applied water quantity and irrigation scheduling is essential for agricultural cultivation in the tidal lowland area in the third planting season or MT3 (June-September). In order to fully understand the irrigation scheduling concept, several processes related to water balance within the root zone must be understood. The governing components are evapotranspiration calculation, the input of soil water and rainfall, soil water content status, crop water requirement, and computer modeling [2, 5]. Irrigation scheduling and calculation of crop water requirements in this research are aided by using BUDGET software [6]. The required data input consisted of climatic data, rainfall, soil characteristics, and crop. The research objectives were to determine the quantity of crop water requirements, irrigation water scheduling, and field strategy related to water application into the crop. The indicator crop was tomato.

## 2. Methodology

### *2.1. Place and Time*

This study was conducted by soil sample taking and observation of land use at Telang Jaya Village of the tidal lowland reclamation area in Banyuasin District from June to July 2020.The land typologi is C type which the tide water could not entry to the land (tertuary block).

### *2.2. Material and Equipment*

This study's materials and equipment consisted of the soil sample, climatic data, daily rainfall at dry and wet seasons, computer software of ETo, and the BUDGET model.

### *2.3. Method*

This study consisted of two stages. The first stage was field activity of soil sampling at a depth of 0-30 cm and 30-60 cm layers for textural analysis in the laboratory. Soil water retention characteristics such as saturated water content, field capacity, and permanent wilting point can be predicted from this soil texture data. This data is important in the calculation of irrigation water scheduling simulation. Observation of field conditions was conducted to access land-use type and water resource potential for irrigation.

The second stage was laboratory work, which consisted of soil textural analysis with the hydrometer and computer simulations. Calculation of crop water requirement (consumptive use) was conducted by calculating potential evapotranspiration which was affected by climatological factors. The calculation model for daily ETo was conducted by using the Penman-Monteith equation with the aid of a computer model of the ETo calculator [7]. Water requirement for the crop is ETo value multiplied by crop coefficient as follows:

$$ET_c = kc\ x\ ET_o \qquad (1)$$

ETc is Crop evapotranspiration (mm/day), ETo is Reference evapotranspiration (mm/day), kc is crop coefficient

Irrigation water scheduling is conducted by using the BUDGET computer model. The BUDGET calculates water content within soil profiles affected by water inflow and water outflow within a certain period. Soil profile generally consisted of several layers that have specific characteristics. At least information on soil texture should be available. The model calculates the change in daily water content storage. The main data input for the model is daily rainfall data, potential evapotranspiration data (ETo), crop data, which consisted of the crop coefficient for each growing stage.

Calculation of irrigation scheduling for tomato crops has consisted of two criteria, i.e., water quantity and water application period that will be given through irrigation. This study's chosen scheduling criteria was a constant time interval with different water quantity applications based on soil water availability conditions or soil moisture. The soil will be irrigated again to fulfill the field capacity of the soil (pF 2.5). The best irrigation scheduling criteria are based on water availability within the soil, which provides the highest efficiency of the irrigation system. Soil should be immediately irrigated before it attains a permanent wilting point condition (pF 4.2). The criterion for the irrigation time used was a constant or fixed interval of 10 days. The selection of this interval period was adjusted to water requirement calculation and rainfall. Operational implementation of irrigation time will be easier to be applied by farmers according to the simulated schedule from the *BUDGET* software. Irrigation was done as an addition to the water supply to fulfill crop water requirements that could not be fulfilled by effective rainfall. Simulation results will show soil conditions with a lack of water that requires farmers to conduct irrigation (real-time irrigation scheduling).

## 3. Results and Discussion

### *3.1. General Description of Study Area*

The field research was conducted at Telang Jaya Village, located at Jembatan II line number 8 (Primer 8), Muara Telang Sub-district. This location is one of the tidal lowland areas which is opened for the transmigration program in 1981. The main water source is from rainfall, and high tidal water only enters channels so that water in the channel only has a function to maintain groundwater table in the land is not quick drawdown.

Telang Jaya Village has four sub-villages and 22 heads of families. This village's distance to the Sub-district capital is 0.2 km, with a traveling time of 5 minutes. Agricultural land in this area is classified as C typology class (rainfed) covering about 960 ha. The previous model of water management network is based on a one-*way flow system* in which high tidal water enters through the primary channel and subsequently into a secondary provider channel in the form of a village irrigation channel (SPD), then into a tertiary provider channel, and finally, flow into farmland. During excessive water conditions (wet season), water from farmland outflow through the drainage tertiary channel and then into the main drainage channel (SDU) and subsequently into the primary channel. However, due to the topography effect and operational conducted by farmers, the flow has two directions. Water supply into the tertiary channel has come from SPD as well as SDU. During the low tide water period, water also flows into two directions, i.e., into SPD and SDU. These two ways, flow water is capable of accelerating the leaching process and more sufficient suplay water during high tide.

Land ownership of farmers is 2 ha consisting of 1 ha Farm Land I (LU-1) and 1 ha Farm Land 2 (LU-2). Nowadays the land ownership had changed in which one farmer may have more than 2 ha of land. The planting pattern depends on land conditions, flooding type, water availability, and the existing drainage network facilities. There are two planting seasons, i.e., Planting Season 1 (MT1) consisting of rice cultivation from November to March and Planting Season 2 (MT2) from March to June. It is encouraged nowadays to have three times planting from June to September for horticultural crops or second crops. The tomato crop has high economic value, although its main constraint is lack of water in the dry season. There is no water supply from high tidal water irrigation, so that surface irrigation is needed.

An overview of the channel system can be seen in Figure 1. The primary channel is to convey water during high tidal periods and as a navigation facility (for water transportation). During the high tidal periods, water supply into secondary channels allows the farmer to collect water in ponds temporarily. The inflow of high tidal water into the channel allows soil water storage in shallow wells provided by a farmer for the irrigation water sources.

**Figure 1**. Primary and secondary channels at Telang Jaya Village

The main soil physical characteristic related to irrigation planning is soil texture. Table 1 showed that soil texture at the root zone (0-30 cm) is clay loam. The higher the clay content, the higher the micropores were, resulting in a low water flow rate within the soil profile. On the other hand, high sand content will provide more micro pores resulting in a high water flow rate. This, in turn, impacts the operational irrigation system in the form of more frequent irrigation applications to crop. This condition is in line with Humphreys research [8], which showed that water content available within the soil profile of clay loam soil (0-1 m) was only 96 mm compared to 180 mm for water content available within clay soil covered with mulch. Therefore, soil with clay loam texture requires more frequent irrigation than that of clay soil. The increase of sand fraction will increase pore space volume so that water flow is faster. Therefore, soils with rough texture will require more water than soil with fine texture [9].

**Table 1**. Analysis results of soil texture at a depth of 0-30 cm

| Parameter | Unit | Value |
|---|---|---|
| Texture | | |
| • Sand | % | 36.91 |
| • Loam | % | 32.25 |
| • Clay | % | 30.84 |
| Textural Class | - | (clay loam) |
| C-organic | % | 4.98 |
| Saturated Water Content | % | 50 |
| Field Capacity Water Content | % | 39 |
| Permanent Wilting Point Water Content | % | 23 |

*Remark: Calculation of soil water retention was done by using the BUDGET computer model*

The study area has wet rainfall potential based on yearly rainfall distribution with an annual rainfall magnitude of more than 4,000 mm. The long dry season occurred in 2015 and 2019. Rainfall at those years was relatively similar to a magnitude of 4,039 mm. Water deficit occurred during the dry season of June to October period, while relatively even rainfall occurred in 2016 and repeated in 2020. Yearly rainfall in 2016 achieved 5,498 mm (Figure 2). This condition will be used as a base for computer simulation of the BUDGET model, i.e., determining real-time irrigation water scheduling during dry conditions (using rainfall data of 2015) and during wet conditions (using rainfall data of 2016). Rainfall occurs relatively frequently if the previous year is a dry condition (2015). Rainfall day numbers in 2105 were 173 days compared to 248 days in 2016. Figure 3 showed that rainfall in 2016 was almost evenly distributed for each month, so that rainfall water volume is higher than that of 2015. The drought occurred again in 2019 (four-year time interval) with a yearly rainfall of only 4,038 mm, which was close to 4,039 mm in 2015. The number of rainfall days in 2019 was also deficient, with a magnitude of 143 days. If the previous year is a long dry season, then it is directly followed by wet conditions. This had happened in 2020 where rainfall conditions were more evenly distributed and farmers do not need to conduct irrigation effort this year.

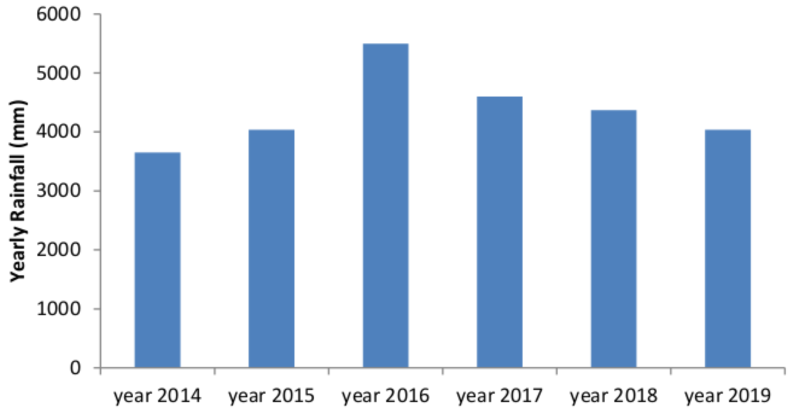

**Figure 2**. Yearly rainfall during five years period at the study area

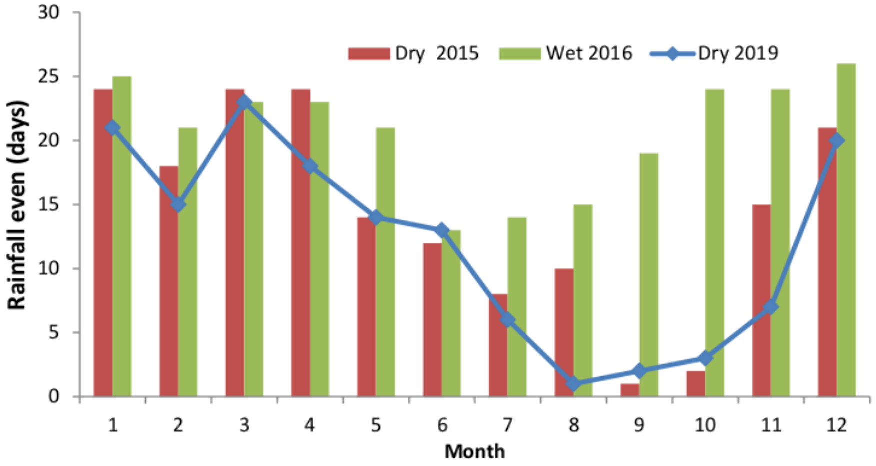

**Figure 3**. Distribution of rainfall days per month at dry and wet climatic conditions.

Yearly rainfall volume at climatic conditions in 2015 and 2019 was relatively similar, but monthly rainfall distribution was slightly different (Figure 4). Water deficit has occurred for four months in the 2015 year (July-October), and it is increased to 6 months in the 2019 year (June-November). This condition causes the South Sumatra area to experience extensive land fire disaster. Therefore, the water deficit period in the 2019 year was occurred from July up to November. In contrast, the water deficit period in 2016 has occurred only for two months (June-July) with a magnitude of less than -20-30 mm/month. This is in line which a previous study which showed that water deficit calculation at Gorontalo area was found in August and September where rainfall was less than potential evapotranspiration (ETP) and water surplus was found in January up to July as well as October up to December where rainfall was higher than potential evapotranspiration (ETp) [10]

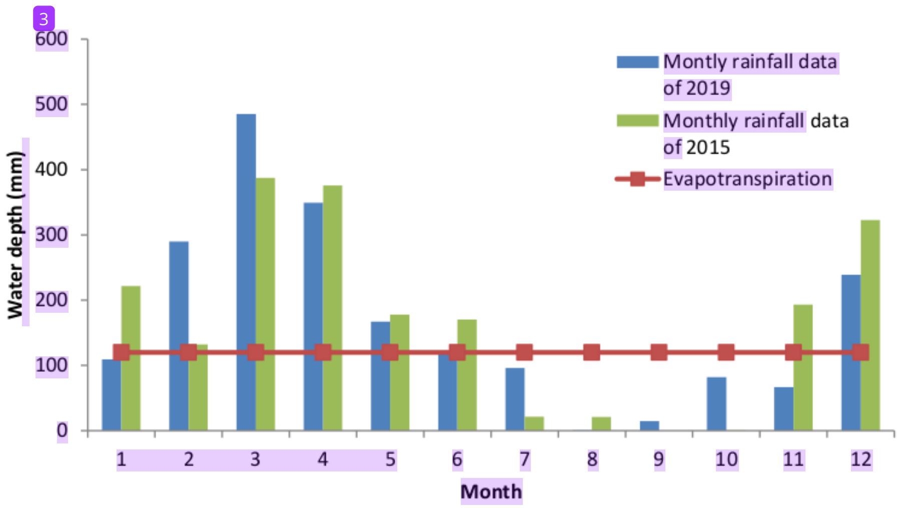

**Figure 4**. Relationship between monthly rainfall during dry and wet climatic condition with crop evapotranspiration.

### *3.2. Analysis of Soil Capability to Store Water and Crop Water Requirement*

Soil solids have consisted of mineral materials and organic matter. Soil mineral is composed of sand, loam, and clay fractions. In addition to solids, soil also has pores space. The proportion of pores space within the soil is always filled with water or air. The pores space's volume is fixed at a specific depth, but it might be changed due to soil tillage or compaction. Water source within soil pores space originates from two sources, i.e., rainfall water or irrigation. The capability of the soil to store water is characterized by pores space magnitude. The soil at the study area has pores space of 50% at the upper layer (0-30 cm), which means that soil can store 50% of applied water from rainfall. If rainfall magnitude is 50 mm and root depth is 30 cm, then water stored by soil is 50/100 x 300 mm = 150 mm. It means that the first rainfall has not yet able to saturate the crop root zone.

Consumptive water requirement is affected by type and age of crop (crop growth stage). When the harvest starts to grow, the value of consumptive water requirement increases according to crop growth, and it will attain maximum value during the maximum vegetative growth period. After achieving maximum value, the value of the consumptive water requirement will decrease in line with seed maturation. The consumptive water requirement of the crop is affected by the crop factor or crop coefficient (kc).

In the calculation of crop water requirement for irrigation application purposes, the different values of crop coefficients (kc) are used which area is based on stages of crop growth. Table 2 showed the value of crop coeficient (kc) of tomato for diffrent growing stage. Crop growth is divided into four growth phases consisting of the initial phase, development phase, middle phase, and final phase. The initial phase is from the germination phase up to the crop's initial growth in which crop closure is less than 10% of the planting area. The second phase is the crop development phase, which is started from the end of the initial phase until the crop is capable of covering soil 70-80% of the planting area. The third phase is the middle phase, i.e., after the crop capable of covering 80% of the soil surface up to begin to mature and enters flowering. The fourth phase is the final phase, where the crop is already mature and production which is ready to be harvested.

Reference crop evapotranspiration is affected by climatic conditions, and this can be calculated by using several methods. To determine the effect of crop characteristics on crop water requirement, then crop coefficient (kc) is a constant that relates ETo to ETc (crop evapotranspiration). The value of kc is related to crop evapotranspiration, which is free of disease, grows in an extensive area with optimum soil humidity and good soil fertility, as well as to attain full production potential at a specific growth environment.

**Table 2**. Crop coefficient of tometo under the different growing stage [7]

| Growth stages | Crop coefficient |
|---|---|
| Initial growth (I) 30 days | 0.60 |
| Vegetative Growth (II) 40 days | 0.75 |
| Generative stage (III) 45 days | 1.15 |
| Fruit formation (IV), 30 days | 0.80 |

For safety reasons in fulfilling water requirement, irrigation application may use the highest value of crop coefficient with a magnitude of 1.10, especially at the third planting season (MT3) at tidal lowland in dry season condition. The evapotranspiration potential (ETo) values of the crop were in the range of 3.8 to 5.3 mm/day. At bright conditions without rainfall and maximum solar radiation, the ETo value was 5.5 mm/day. However, during October month due to smoke effect had caused a decrease in solar radiation so that ETo value was decreased in the range of 3.5 to 3.8 mm/day. If tomato crop growing requires a cultivation period of 60 days, then at least the required water was (4.5 mm/day x 1.1 x 60 day) = 297 mm.

Field research conducted by Jaya Negara et al. [11] showed that irrigation water requirement for tomato crops highly depends on crop growth phases. The fastest-growing cultivation period of tomato is 56 days. The phases for tomato crop growth are as follows: initial growth of 16 days, vegetative phase of 20 days, fruit formation phase until an initial harvest of 20 days. The average crop water requirement for a tomato at the initial phase was 3.5 mm/day, vegetative phase until fruit formation was 4.5 mm/day, and subsequently decrease prior to the harvest phase. Thus, the total water requirement for the crop in the field was about 266 mm. This value was not much different than the value obtained from a computer simulation.

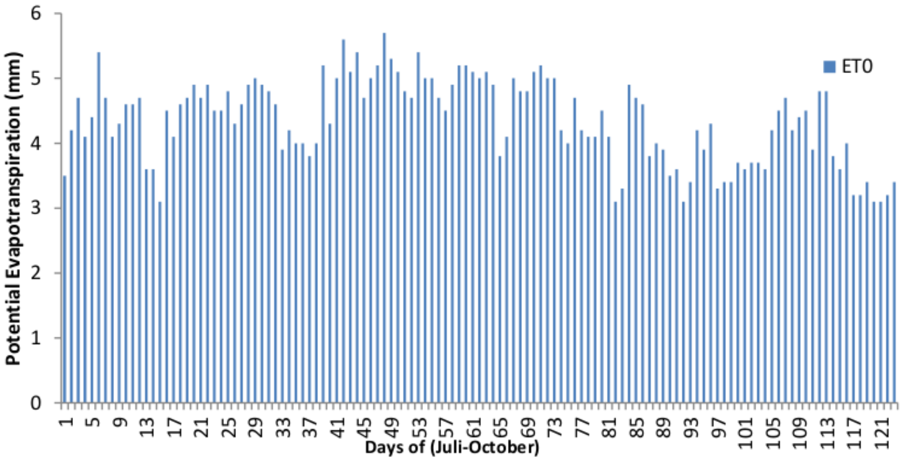

**Figure 5**. Daily dynamics of potential evapotranspiration values at Telang I area

### *3.3. Irrigation Water Scheduling for Tomato Crop at Tidal Lowland Area*

The crop cultivation scenario was a dry climate condition in 2019 with deficient rainfall for the planting period of July to October. During the crop growing period, water balance in the land was in water deficit condition (-) in which monthly rainfall was much smaller than the evapotranspiration value. This condition requires the farmer to conduct irrigation. Consideration for crop cultivation at dry season was because the first and second planting seasons were still prioritized for rice crop and vegetable product prize at dry season is usually higher.

Irrigation scheduling has two main objectives: when and how much water should be applied to crop. Calculation of irrigation water requirement and irrigation water scheduling is usually based on three approaches: crop monitoring, soil water monitoring, and water balance analysis technique. Approaching a concept based on monitoring of crop growth condition and soil water monitoring requires high cost and a long time so that analysis technique based on soil water balance within crop root zone is the leading choice—monthly rainfall distribution at dry climatic condition (Figure 6).

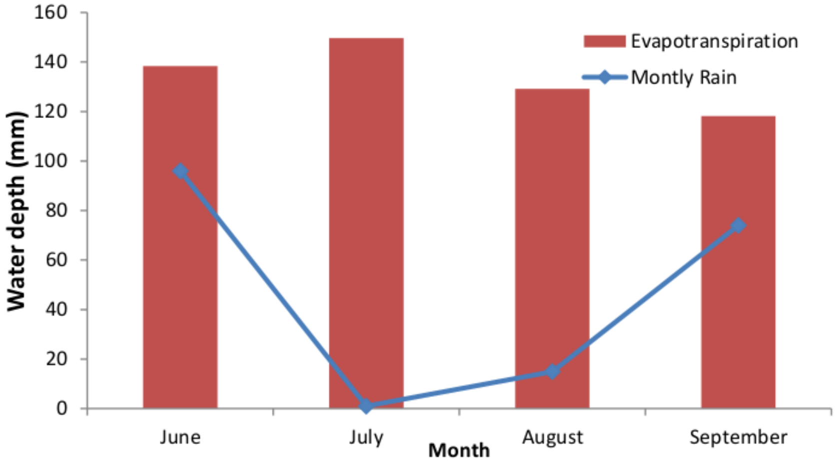

**Figure 6**. Monthly water balance at dry season condition in 2019

At the condition of an intense soil water surface (> 90 cm), capillary water's contribution is not sufficient to fulfill crop water requirement, so that irrigation is needed. Soil water dynamics during the end of the rainfall season period (April) and entering the dry season (July-August) can be seen in Figure 7. Therefore, computer simulation of the BUDGET model no longer enters soil water contribution as a water source.

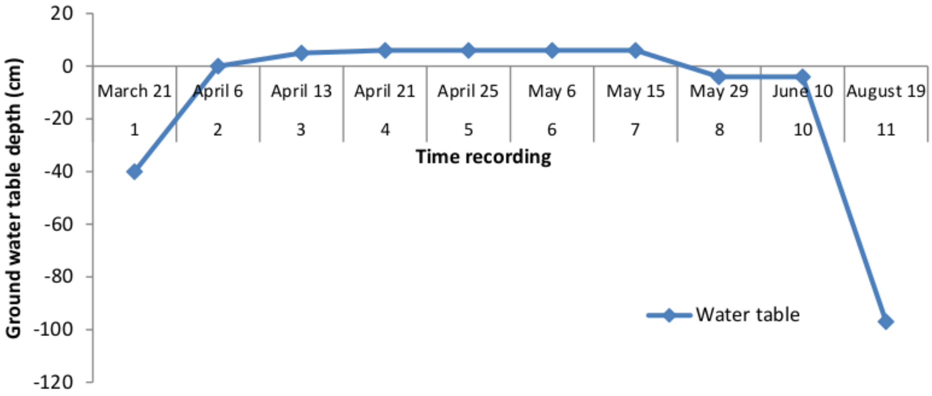

**Figure 7**. Soil water dynamics for the period of March to August 2020.

The planting period up to harvest was 145 days. Computer simulation results of the BUDGET model showed that there were ten times watering during the crop growth period with a total crop water requirement of 450-490 mm. More frequent watering was done at the initial growth period, i.e., once every 5-7 days, and watering was done once every ten days starting from the middle season up to the final period.

The computer simulation was perfect because it was supported by previous research [12], which showed that irrigation interval application for tomato crop at swampland was eight days and produced the best production with a magnitude of 1.280 kg.crop$^{-1}$ or equal to 28.4 ton.ha$^{-1}$.

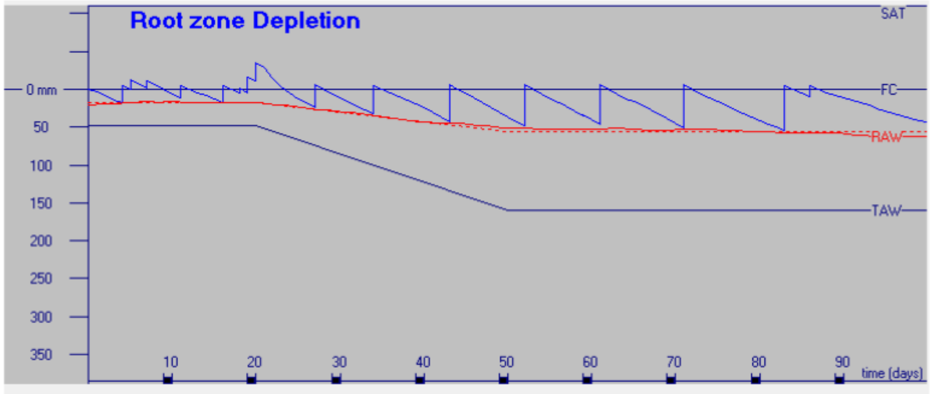

**Figure 8.** Irrigation water scheduling for tomato crop planted on 1 July 2019.

However, the dry season's watergate operation in the field was better conducted by using a close system to collect rainfall water. The tertiary channel should contain water at a minimum height of 80-100 cm or -30 cm from the embankment so that soil water in farmland was available at a depth of 30-40 cm. At a soil water depth of 20-40 cm, crop water requirement can still be supplied from the capillary water movement, and it is appropriate for vegetable crop growth such as tomato. The research for corn crops showed that the soil water surface drops up to 1 m depth, capillary water movement can only be supplied 41 % of the crop evapotranspiration requirement [13]. Field drilling at the dry season in August 2020 showed that soil water surface was already at a depth of 90 cm. This condition showed that food crop cultivation should be provided with additional water supply from surface irrigation.

The second simulation (Figure 9) was conducted at a relatively wet climatic condition using the daily rainfall data of the 2016 year. This year's total yearly rainfall was more than 4000 mm, and it was evenly distributed throughout the year. The dry season period in June-August 2016 showed that rainfall occurrence was in the range of 10 to 15 days. Planting was still done from the July period. The simulation result showed that rainfall was sufficient to fulfill crop water requirements so that irrigation water was no longer needed in order to maintain soil moisture at field capacity conditions.

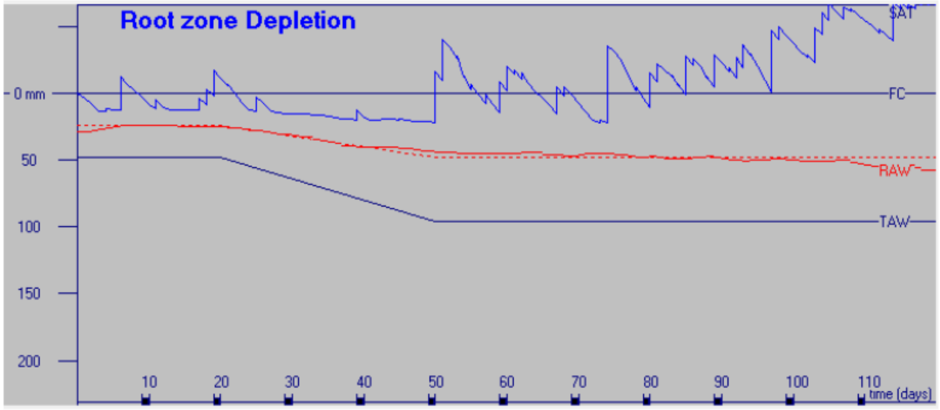

**Figure 9**. Condition of soil water status during the planting period of June

*3.4. Irrigation Water Application in Field*

Laboratory analysis results of soil texture in crop root zone showed that soil texture was clay loam. This soil has water retention characteristics as follows: saturated water content of 50%, field capacity water content of 39%, and permanent wilting point of 23%. Saturated water content represents the condition of total pore space. Therefore, the soil porosity value was also 50%. Soil capability to store water is 50%. Irrigation water scheduling shown in the BUDGET model was conducted to restore soil at field capacity. Still, farmers in the field conduct irrigation practice until saturated soil conditions (all pore space are filled with water). Irrigation usually was applied when readily available water was already run out. Simulation results showed that watering was conducted once a week (first month) at the initial growth period and once every ten days for the second and third months.

Irrigation water application within the root zone at a depth of 30 cm with total porosity of 50% had produced water storage thickness of 50/100 x 300 mm = 150 mm. If the area of crop planting is 1 ha (10,000 $m^2$), then the water volume that should be given was 1,500 $m^3$.The existing water resource utilizes high tidal water, which flows into a tertiary channel or rainfall water retention (Figure 10). Using open water gate operation, water in the tertiary channel only has a depth of 30-50 cm, which was insufficient for pump irrigation. But, if water gate operation was conducted by using high tidal water supply and rainfall water retention, then water in the tertiary channel had attained a depth of 110 cm, which is sufficient for pump irrigation.

(a) (b)

**Figure 10**. Tertiary channel condition (a) less water at the opened gate and (b) more water due to detention operation

Pump irrigation application is the last choice when high tidal water cannot fulfill the farmland's water requirement. Land in the study area is categorized as C flooding type where high tidal water cannot overflow the land. Therefore the water management objective is to harvest rainfall water and retaining water in the tertiary canal after tidewater. Water can only enter into the tertiary channel. Irrigation water supply can only be applied by pumping (Figure 11).

**Figure 11.** Equipment for the pump irrigation system at tidal lowland area of Telang I

The farmer usually plants vegetable crops by using a dike system so that irrigation application was conducted using the furrow irrigation model (Figure 12). Water is pumped from the tertiary channel into a quarterly channel, or sub-tertiary channel, which will subsequently fill the trenches among crop dikes.

**Figure 12.** Vegetable crops in the field using the furrow irrigation system

## 4. Conclusion and Recommendation

Land use analysis showed that the study area had the potential for three times planting (PI 300) with a rice-rice-vegetable planting pattern. The cultivated vegetables usually were string bean, etc. Tomato plant cultivation needs to be socialized. The simulation result for the tomato crop showed that crop water requirement was in the range of 450 to 490 mm. Irrigation water scheduling at dry climate (2019) showed that irrigation intervals were once every week for one month and subsequently once every ten days. Meanwhile, simulation results for wet climatic conditions showed that irrigation was not required, and watergate operation was done using a retention system to maintain soil water surface at a depth of 30-40 cm. The irrigation stratrgy to achieve crop evapotranspiration during dry period in tidal lowland is to retain water in tertiary canal and rainfall harvesting method. Irrigtion water suplay to field area (tertiary block) should be done by the pump irrigation system. Water resource at the tidal lowland area of Telang 1 was from rainfall water and high tidewater. High tide water at C-land typology could not enter into farmland, so that pump irrigation is required. Application of pump irrigation for 1 ha land requires an operational time of 5 hours with an average water discharge of 0.077 $m^3$/s.

## References

[1] Imanudin, M S and Armanto M E, 2019 Determination of Planting Time of Watermelon Under a Shallow Groundwater Table in Tidal Lowland Agriculture Areas of South Sumatra, Indonesia *Irrig. Drain.* **68** 3 pp 488-95.

[2] Gu Z, Qi Z, Burghate R, Yuan S, Jiao X, and Xu J, 2020 Irrigation scheduling approaches and applications: A review *J. Irrig. Drain. Eng.* **146** 6 p.04020007.

[3] Imanudin M S, Satria J P, Bakri B, and Armanto M E 2020 Field Adaptation for Watermelon Cultivation under Shallow Ground Water Table in Tidal Lowland Reclamation Area *J. Wetlands Environ. Manag.* **8** 1 pp 1-10.

[4] Kadioglu H, Hatterman-Valenti H, Jia X, Chu X, Aslan H, and Simsek H 2019 Groundwater Table Effects on the Yield, Growth, and Water Use of Canola (Brassica napus L.) Plant *Water* **11** 8 p 1730.

[5] Fernández García I, Lecina S, Ruiz-Sánchez M C, Vera J, Conejero W, Conesa M R, Domínguez A, Pardo J J, Léllis B C, and Montesinos P 2020 Trends and Challenges in Irrigation Scheduling in the Semi-Arid Area of Spain *Water* **12** 3 p 785.

[6] Raes D 2002 BUDGET model. A soil water and salt balance model. K.U.Leuven Faculty of Agricultural and Applied Biological Sciences Institute for Land and Water Management.

[7] FAO 2009 Irrigation and Drainage Paper No 56.: "Crop Evapotranspiration" ETo calculator downloaded http://www.fao.org/land-water/databases-and-software/eto-calculator/en/

[8] Humphreys E, White R J G, Smith D J, and Godwin D C, 2008 Evaluation of strategies for increasing irrigation water productivity of maize in southern New South Wales using the MaizeMan model *Aust. J. Exp. Agric.* **48** 3 pp 304-12

[9] Minasny B and McBratney A B, 2018 Limited effect of organic matter on soil available water capacity *Eur. J. Soil Sci.* **69** 1 pp 39-47.

[10] Rahim Y, Rogi J E, and Runtunuwu S D, 2015 Pendugaan defisit dan surplus air untuk pengembangan tanaman jagung (Zea mays L.) di Kabupaten Gorontalo dengan menggunakan model simulasi neraca air *Agri-sosioekonomi* **11** 1 pp 11-17.

[11] Negara I D G J, Budianto M B, Supriyadi A, and Saidah H, 2020 Analisis kebutuhan air tanaman dengan metode caoli pada tanaman tomat dengan irigasi tetes di lahan kering lombok utara *Ganec Swara* **14** 1 pp 419-25.

[12] Sy E M and Idrus M, 2010 Pengaruh Interval Waktu Pemberian Air terhadap Produktivitas Tanaman Tomat di Lahan Kering Dataran Rendah pada Musim Kemarau *Jurnal Penelitian Pertanian Terapan*, **10** 3 pp 207-12

[13] Gao X, Huo Z, Qu Z, Xu X, Huang G, and Steenhuis T S, 2017 Modeling contribution of shallow groundwater to evapotranspiration and yield of maize in an arid area *Sci. Rep.* **7** 1 pp 1-13.

# Real-time irrigation scheduling for upland crop based on soil and climatecharacteristics of tidal lowland area in South Sumatera

ORIGINALITY REPORT

| 6% | 6% | 6% | 6% |
|---|---|---|---|
| SIMILARITY INDEX | INTERNET SOURCES | PUBLICATIONS | STUDENT PAPERS |

PRIMARY SOURCES

| | | |
|---|---|---|
| 1 | Submitted to Universitas Jenderal Soedirman<br>Student Paper | 4% |
| 2 | repository.petra.ac.id<br>Internet Source | 1% |
| 3 | Submitted to Sriwijaya University<br>Student Paper | 1% |
| 4 | Submitted to Universitas Brawijaya<br>Student Paper | 1% |

| | | | |
|---|---|---|---|
| Exclude quotes | On | Exclude matches | < 1% |
| Exclude bibliography | On | | |