Bachelor of Biosystems Technology
Faculty of Technology
South Eastern University of Sri Lanka

BSE 11042 Principles of Irrigation

Assignment 1c Professor M.M.M. Najim

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Irrigation Water Requirements and Scheduling

Aim:
To calculate irrigation schedules using the climate/ET_o, Rain, Crop and Soil data used in Exercise 1b - i.e. how to find out how much irrigation water to apply and on what dates.

1 - Know the difference between Crop Water Requirements and Irrigation Water Requirements
2 - Understanding scheduling criteria
3 - "optimal" scheduling criteria : calculated automatically by CROPWAT
4 - "practical scheduling criteria: you define the irrigation timing and amounts of water
5 - scheduling criteria effect on crop yield

Data available
Climate/ET_o, Rain, Crop and Soil data from Assignment 1b.
Crop data for depletion fraction and yield reduction

Method

- If you have just completed Assignment 1b and CropWat is still on the screen, you will have only to enter the irrigation scheduling criteria.
- If you have exited CropWat after Assignment 1b you will also have to open the saved data files Climate/ET_o, Rain, Crop, Soil, Planting date, and Crop Pattern.
- Once the data is entered, we will use an optimal irrigation scheduling method so that CropWat will calculate a daily soil moisture balance and predict when the crop needs to be irrigated and also the amount of water to apply.
- You will be able to look at tables and graphs of the predicted changes in soil moisture content and the estimate of crop stress (water deficit) on crop yield.
- Finally, we will change the irrigation scheduling methods to and look at the effects of crop stress (water deficit) on crop yield.

Reminder - how is an irrigation schedule calculated?

Crop Water Requirement (CWR) is the amount of water the crop needs to grow. (Remember that this does not include any leaching requirement). It is calculated in CropWat using CWR=(ET_o)*(K_c)*(area planted). CWR will change week by week depending on the values of K_c and ET_o.

Irrigation Water Requirement (IWR) is the amount of water we have to supply to satisfy the crop water requirement. If there is no rainfall or contribution of water from the water table then

IWR = CWR. In many countries rainfall contributes to the CWR. IWR is calculated using IWR=(CWR)-(Effective Rainfall).

To calculate an irrigation schedule we have to know when the soil moisture deficit reaches a critical level - i.e. when the crop is likely to become stressed due to lack of water. To do this, we have to make a daily water balance calculation. We usually assume that the soil is at field capacity at the start of the growing season. CropWat calculates IWR for each day and reduces the soil moisture content at the end of each day.

The critical level, when the crop becomes stressed, is called the limit of Readily Available Moisture (RAM) in the soil. RAM is calculated from

TAM = (Root depth)*(Soil moisture capacity in mm/metres)

and

RAM = TAM * P

TAM is the total available moisture in the soil, in units of mm of water per metre thickness of the soil.

Most crops will die long before all the soil moisture is used, so we set a limit to how much of the total water is used before the crop is stressed. This limit is the "**P**" fraction, which is used to convert Total Available Moisture to the Readily Available Moisture. Typical values for "P" are 40-60% i.e. RAM is 0.4 to 0.6 of TAM.

Note that as the season progresses, the crop root depth increases as the crop grows, so the TAM and RAM will also increase (see Table 2 in Exercise 1b).

An optimal irrigation schedule will irrigate so that the crop never becomes stressed and no water is wasted by over irrigating. In this way water use is minimized and crop yield should not be reduced.

CropWat will work out an optimal schedule by calculating the soil moisture balance for each day until all the Readily Available Moisture has been used. After this the crop will become stressed. CropWat will calculate the first irrigation on this date. The amount of irrigation water will be equal to that needed to return the soil to field capacity. CropWat will then continue for the rest of the growing season, calculating daily soil moisture deficits and indicating irrigation each time all the RAM is used up.

METHOD : (HOW TO DO IT)

1 If you are continuing from Assignment 1b, go on to step 2.

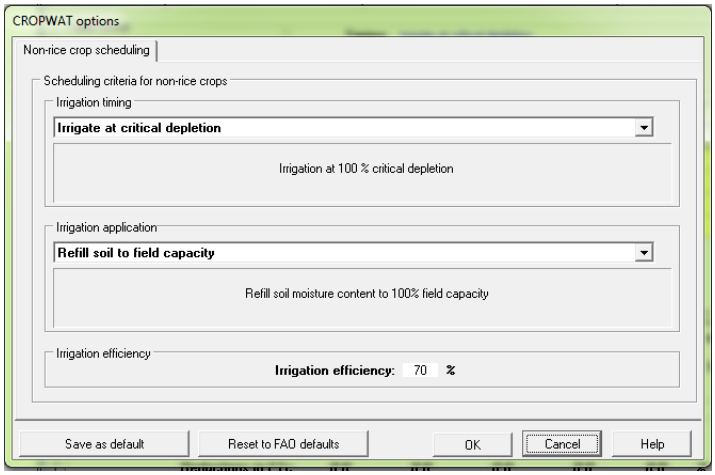
If you have already completed Assignment 1b and you have exited from CropWat between the end of Assignment 1b and this exercise, open all the data files by clicking the Climate/ET_o, Rain, Crop, Soil, Planting date, and Crop Pattern icons on the left hand side of the screen.

(If you have not done Assignment 1b, you have to go back to Assignment 1b and complete it.)

2 Scheduling Criteria

At this point you have entered all the data needed to calculate an irrigation schedule. However, it is still necessary to tell CropWat the basis on which to make the schedule (irrigation timing and irrigation application). This is called the Scheduling Criteria. CropWat allows you to set these criteria in many different ways. In this exercise we will use optimal irrigation first and then use other scheduling criteria.

Select the **Schedule** button from the left side menu and then from the main menu select the **Options** button. Then the following screen will pop up to select scheduling criteria for non-rice crops.



These CropWat will allow you to select many options as follows.

Irrigation timing

i. irrigate at critical depletion - irrigation is done at 100% critical depletion
ii. irrigate at user defined intervals – the user defined irrigation intervals can be set where irrigation done at how many days after planting and irrigation depths at each irrigation event.
iii. irrigate at below or above critical depletion – where the user can define the depletion %
iv. irrigate at fixed interval per stage – the irrigation interval at each stage can be separately given by the user
v. irrigate at fixed depletion – the user can set the amount of depletion as a depth
vi. irrigate at given ETcrop reduction per stage – the user can define the % reductions per stage
vii. irrigate at given yield reduction – to irrigate at a user defined percentage yield reduction
viii. no irrigation – rainfed condition is considered without no irrigation

Irrigation application

i. user defined irrigation depth – the user defined irrigation depths can be set where irrigation done at how many days after planting and irrigation depths at each irrigation event.
ii. refill soil to field capacity - refill soil moisture content to 100% of the field capacity)
iii. refill soil above or below field capacity – the user can define the to be refilled as a percentage of field capacity
iv. fixed application depth – the user can define a fixed irrigation depth

Irrigation efficiency

Can be changed according to the field efficiency values (at the beginning it is 70%).

With the combinations of the above scheduling criteria, the CropWat will do the irrigation scheduling. Once you apply a set of schedules, you may save the schedule file assigning an appropriate name.

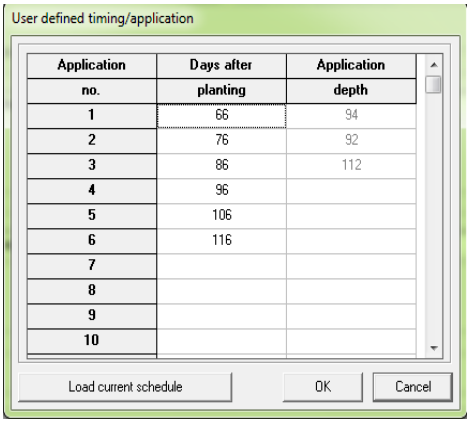
Cropwat will now automatically calculate

- A daily soil moisture balance
- WHEN the soil moisture deficit equals the limit of the readily available moisture
- THE AMOUNT of irrigation water needed to re-fill the soil to field capacity
- It will repeat these calculations until the end of the growing season
- Next it will find totals of Crop ET, Effective rainfall and Irrigations applied
- Finally it estimates crop yield reduction due to any crop water stress.

3. You can look at the results by either in tables or on graphs. It is suggested to look at the graph first, because it is easier to understand. The graph shows changes in soil moisture deficit during the growing season.

4. The user can adjust the net irrigation supplied in the table which gives crop irrigation schedule and observe the yield reduction and other changes taking place.

5. The students have to check the results with different scheduling options and combinations of options.



a) Select user defined intervals as the irrigation timing and irrigation application to refill upto field capacity. Check your results.

b) Select user defined intervals as the irrigation timing and irrigation application to user defined application depths. For each irrigation event enter 30 mm. Check your results. Check the chart to see that at some points, the crop is stressed as depletion levels goes beyond RAM levels. Therefore, you can observe a yield reduction.

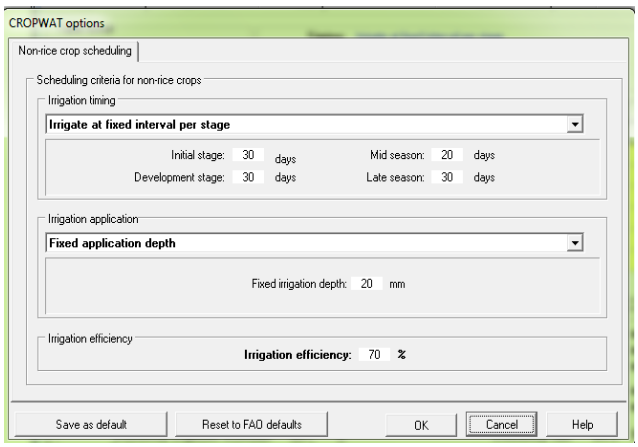
c) Select irrigate below or above critical depletion as the irrigation timing and irrigation application to refill upto field capacity. Adjust the critical depletion percentage as 120%. Check your results. Check the chart to see that at some points, the crop is stressed as depletion levels goes beyond RAM levels. Therefore, you can observe a yield reduction.

Then adjust the critical depletion percentage as 60%. Check your results. As it is irrigated when 60% of the depletion level reached, the total RAM is not used. Crop performs without any yield loss.

d) Select irrigate below or above critical depletion as the irrigation timing and irrigation application to refill below or above field capacity. Adjust the critical depletion percentage as 120%. Adjust the refill moisture content to 120% of field capacity. Check the results. Check the chart to see that at some points, the crop is stressed as depletion levels goes beyond RAM levels. In addition, as more irrigation is done, at the irrigation, some over irrigation has taken place. This has reduced the efficiency of the irrigation schedule (check the schedule table. You could have noticed that in the previous cases, the efficiency was 100%).

e) Select rain fed cultivation as the irrigation timing. Observe the yield reduction.

f) Select irrigate at fixed interval per stage as the irrigation timing and irrigation application to refill upto field capacity. Give different intervals for different stages and check your results.



g) Select irrigate at fixed interval per stage as the irrigation timing. Give different intervals for different stages (30, 30, 20, 30 for initial stage, development stage, mid season stage and late season, stage, respectively) and irrigation application to fixed application depth (20 mm) and check your results. Then increase the irrigation depth to reduce the yield loss.

h) Try with other combinations of scheduling.

i) CropWat can be used to schedule rice irrigation also.