NATURAL RESOURCES SYSTEMS PROGRAMME

***PROJECT REPORT*[1]**

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Report Title

Water productivity and irrigation scheduling.

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NRSP Production System

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6. Water Productivity and Irrigation Scheduling

Objectives of the module

After having completed this exercise you will be able to:

- Determine proper timing and amount of water to apply to realise maximum yield
- Determine the water productivity
- Use the PT agro-hydrological model and produce some output
- Plot and tabulate outputs from PT model using Microsoft Excel and produce a simple report using Microsoft Word

Requirements for the module

- Weather data files
- Soil profile description (texture class, initial soil water)
- Start dates for different growing seasons
- Planting dates for different seasons
- Location of the areas (latitude),size of the area under cultivation, slope, surface characteristics (mulching)
- Type of crop to be grown and plant population
- Field management practises (bund height, initial roughness of the soil)
- If it's a crop grown under ponding conditions (e.g. paddy rice), maximum number of ponded days, critical ponding depth
- Irrigation scheduling criteria
- Spreadsheet and word processing packages such as Microsoft Excel and Microsoft Word

6.1 Irrigation scheduling

Irrigation scheduling is the process of determining when to irrigate and how much water to apply per irrigation. Proper scheduling is essential for the efficient use of water, energy in case of pressurized irrigation and other production inputs. Proper scheduling also allows irrigation timing to be coordinated with other farming operations such as cultivation, pesticides and fertilizer applications. Among the benefits of proper irrigation scheduling is: improved crop yield and/or quality, water and energy conservation and low production costs.

Important terminology and their definition on irrigations scheduling are shown in Table 6.1 and Figure 6.1.

Table 6.1. Definitions of irrigation scheduling terminology

Term	**Definition**
Root zone depletion	Expresses the shortage of water in the root zone with respect to its maximum water holding capacity.
Maximum depletion	Is the maximum amount of water that a crop can extract from the soil without suffering water stress, i.e. the readily available soil moisture (RAM).
Water application depth (DA)	Is the amount of irrigation water applied in equivalent water depth, DA (mm water), and depends on the soil water holding capacity
Water application duration (WAD)	Time required to supply water application depth, expressed in seconds, minutes or hours, normally given per hectare per crop
Irrigation application interval (i)	The water application timing depends on the choice one makes; water application can be related directly to soil moisture content, which results in different intervals; but very often water application is done at fixed intervals and soil moisture content will then vary. The time between successive water applications is called the irrigation interval (i) and is measured from the start of one water application to the start of the next water application and therefore includes the water application duration (WAD),The irrigation interval is basically expressed in seconds, but ultimately (in the schedule) will be expressed in hours or in days or in both.

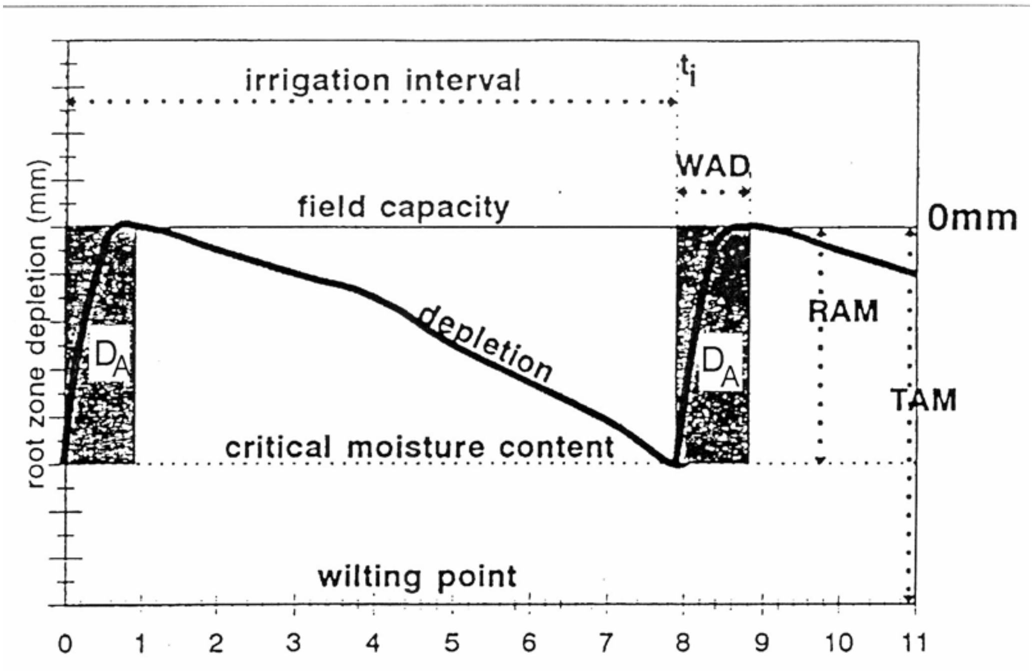

Figure 6.1. Graphical presentation of irrigation scheduling terminology

6.2 Scheduling strategies

Irrigation schedules are designed to either fully or partially provide the irrigation requirement. These strategies are discussed in the following paragraphs:

6.2.1 Full Irrigation

Full irrigation involves providing the entire irrigation requirement and results in maximum production in accordance with the respective production function for a given crop. Exceeding full irrigation reduces crop yields by reducing soil aeration and restricting gas exchange between the soil and atmosphere. Full irrigation is economically justified when water is readily available and irrigation costs are low. It is accomplished by irrigating to minimize the occurrence of plant stress (i.e., irrigating so that actual transpiration rates do not drop below potential rates).

6.2.2 Deficit Irrigation

Partially supplying the irrigation requirement, a practice that has been called deficit irrigation, reduces yield as smaller amounts of water, energy, and other production inputs are used to irrigate the crop. Deficit irrigation is economically justified when reducing water applications below full irrigation causes production costs to decrease faster than revenues decline (because of high production costs and the relatively flat slope of production functions in the vicinity of full irrigation). Application levels can be reduced below full irrigation until the slope of the production function is such that the decrease in revenue due to an incremental reduction in water application equals the accompanying decline in production costs. Irrigations should be scheduled to apply the seasonal application at this point of the production function, since net benefits of irrigation are maximized.

Deficit irrigation is also used when the water supply or the irrigation system limit water availability. In these situations the level of irrigation, the amount of land to be irrigated, and the crop mix that maximize the benefits of irrigation must be determined. With the rising

water scarcity concerns, it is more and more important to ensure that water resources are used in a way that is more effective to meet societal goals. Increase in water productivity, i.e. producing more with less water, are seen as potentially powerful solution. Water productivity in agriculture can take many forms but most commonly, it is used to refer to the amount of "crop per drop", related to kilograms of crop produced per drop of water.
Deficit irrigation is accomplished by allowing planned plant stress during one or more periods of the growing season. Adequate water is supplied during critical growth stages to maximize water use efficiency (i.e., maximizing crop production per unit of water applied).

6.2.3 Practical irrigation schedules

Although plants and soil indicators may in theory be the most ideal for scheduling irrigations in real time, their applicability is limited due to a number of factors such as limited access to specialized equipment for monitoring the water status of plants and soil in the field by ordinary farmers. Hence more practical irrigation schedules are commonly applied.

6.3 Scheduling under ideal conditions

Ideally irrigation schedules should be based on the actual needs of the crop as shown graphically in Figure 6.2. The steps that lead to the development of the graphical representation are as follows:

- Plot soil moisture depletion on the Y-axis, with zero depletion as field capacity.
- Plot the time on the X-axis and indicate months and decades since sowing/planting.
- For each decade of crop growth plot the readily available water (RAM = p. D. Sa), and draw a line through the points (1).
- For each decade calculate In mm/day and, starting with soil moisture equal to field capacity on day zero, plot cumulative daily values of I_n. This results in line (2). When this line touches graph (1) draw a vertical line (3) to the horizontal axis (soil moisture depletion equal zero). The point on the X-axis indicates the time, that water is (should be) applied.
- Determine the irrigation interval and the application depth (DA), which is equal to the length of the vertical line.
- Repeat steps 4 and 5 for the whole season.
- The time (date) of application and depth as obtained from the plot are used as input to the PT model.

Unfortunately actual conditions are far from ideal. In the first place, irrigation schedules where the application depth and the irrigation interval vary constantly over the season may create serious problems in practice. Not only does it require considerable skill from the irrigators and from the farmers, but it also creates peak water demands at certain times while at other times water requirements will be below average. Many systems can not deal with such a situation, more so when water availability is restricted. Also water supply may not be under the direct control of the scheme management. For gravity irrigation under restricted water supply, rotational supply is normally practiced, indicating not only fixed intervals, but also fixed volumes. Under less restricted water supply and different irrigation methods other options are possible as discussed below.

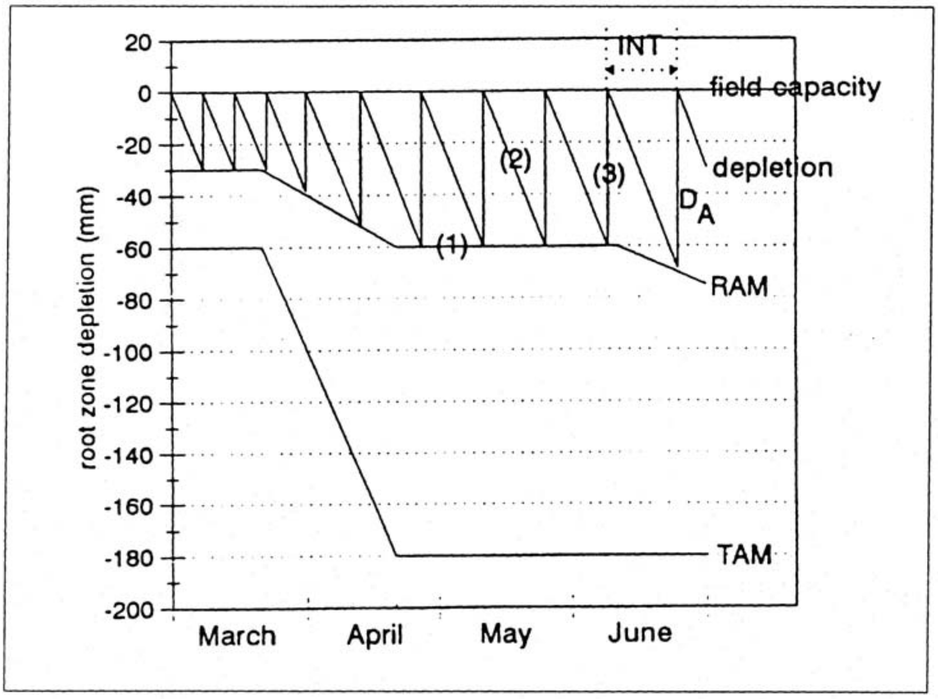

Figure 6.2. Graphical illustration of scheduling under ideal conditions

Notation:

I_n	: net irrigation requirement
RAM	: readily available moisture (water)
p	: depletion factor, i.e. fraction of the total available soil water (Sa) that a crop
can	:extract from the soil without suffering water stress.
Sa	: total available soil moisture
D	: depth of the root zone

6.3.1 Variable interval(s), fixed amount(s)

In this case a fixed application depth (DA) is selected and the interval length has to be adjusted to the (net) irrigation requirements. The flexibility in the timing of the successive applications will then determine the extent of over- or under-irrigation. Figures 6.3 and 6.4 give two graphical examples of this case: the first (DA= 50 mm at 7 and 14 days interval) resulting in heavy water losses and the second (DA= 30 mm at 7 and 14 days interval) in serious water stress. A certain over-irrigation in the beginning may not be lost completely, as it may increase soil moisture below the actual root zone, which will be of benefit to the crop after its roots reach a greater depth.

For this particular exercise different combinations of application depth and irrigation intervals can be tried with the PT model to see which combination results in higher productivity.

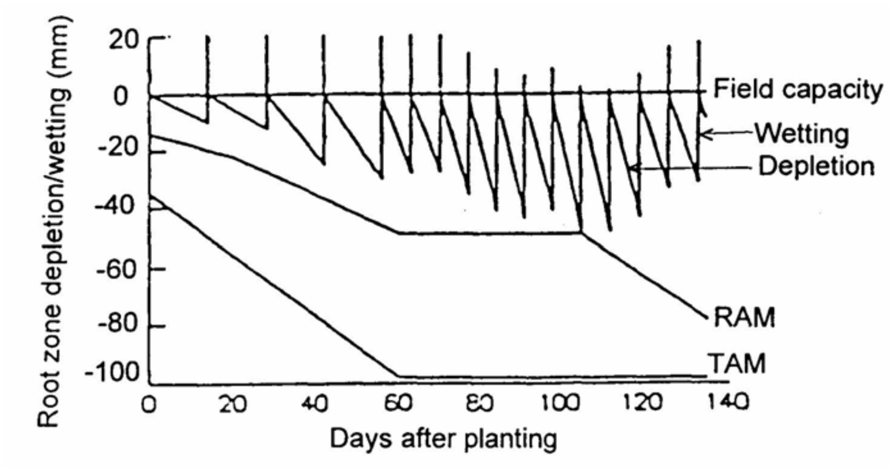

Figure 6.3. Graphical illustration of fixed amount (50 mm) at 7 and 14 days interval

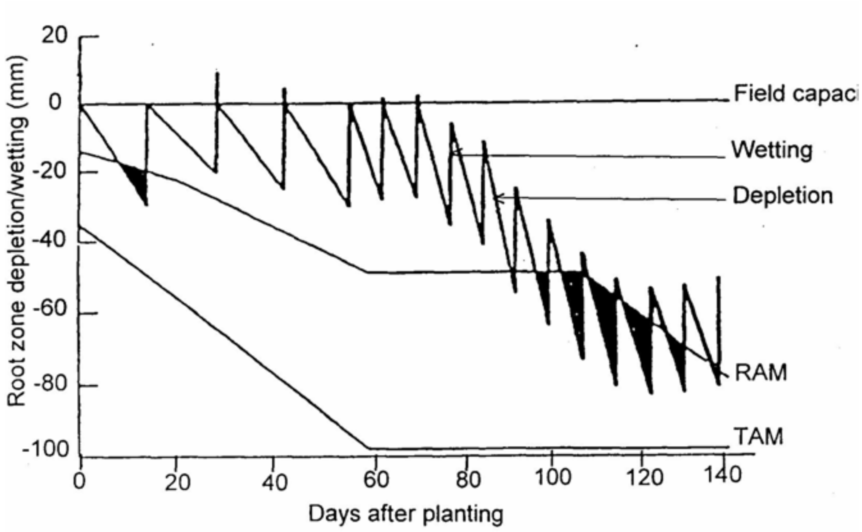

Figure 6.4. Graphical illustration of fixed amount (30 mm) at 7 and 14 days interval

6.3.2 Fixed interval(s), variable amount(s)

The application depth can be determined to conform to the deficit at the end of each fixed interval (θ_{FC} - θ_i).When soil moisture depletion exceeds readily available moisture ($\theta i > C_{ritical}$) water stress is bound to occur, resulting in yield reduction.
Again for this exercise, different combinations of application depths and irrigation interval can be tried.

6.3.3 Fixed intervals and fixed amounts

This is the most frequently used distribution method for gravity irrigation with rotational supply. Both the interval(s) and the amount(s) may not correspond to the soil moisture conditions, i.e. the amount may exceed or fall short of soil moisture depletion or the water requirements for the fixed interval may not correspond with readily available soil moisture.
If the system allows, different intervals and amounts should be used for the different crop stages, but even that is often not possible. However there are some options available to restrict yield reduction:

- The amount should be large enough so that depleted soil moisture can be replenished also during the mid-season;

- Use of the readily available soil moisture for crop growth i.e. depletion of RAM over the growing season. This means that at the end of the season soil moisture may be completely depleted over the maximum root depth and should be replenished before planting/sowing of the next crop (Figure 6.5).

In this exercise, different combinations of fixed interval and fixed amount can be tried and the best performing combination in terms of productivity, identified.

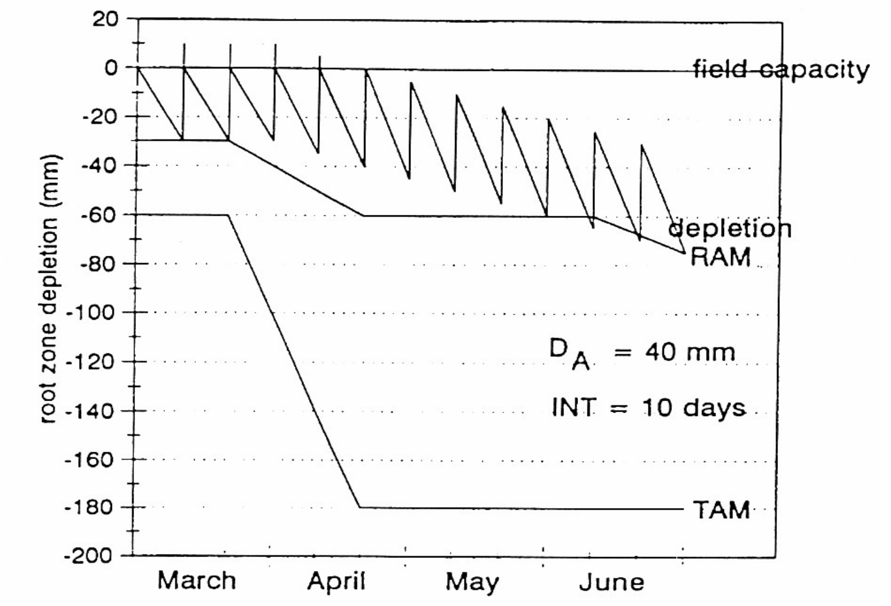

Figure 6.5: Graphical illustration of fixed interval and fixed amount

6.3.4 Scheduling under deficit irrigation

Often water availability or actual water supply is limited and below irrigation requirements. There is not enough water to replenish soil moisture up to field capacity and to irrigate before all of the readily available soil moisture (RAM) is depleted. Consequently the crop will experience water stress, to a degree depending on it's growth stage, its sensitivity to water stress and the seriousness of the soil moisture deficit.

Yield response to water can be expressed as:

$$Y_a = \alpha ET_{act} + \beta \quad (1)$$

Where:

$$\alpha = k_y \frac{Y_m}{ET_{crop}} \quad (2)$$

And

$$\beta = (1 - k_y)Y_m \quad (3)$$

Where:

Ya = actual harvested yield

Ym = max. possible yield
ETact = actual crop evapotranspiration
ETcrop = potential crop evapotranspiration
ky = yield response factor

There is thus a linear relationship between actual yield and actual evapotranspiration, which can be established for known climate (ET_o), crop and crop stage (k, and ky factors, Ym, and ET_{crop}).
Options for irrigation scheduling under conditions of water stress are as follows:

- Accept a reduction in ETcrop (ETact = ξETcrop), which results in an acceptable Ya value [Ya= {1-(1-ξ).ky}.Ym]. Determine the irrigation schedule for the given conditions and evaluate water savings (is the water availability covering the reduced water requirements?).
- Accept an economically acceptable reduction in Ya and calculate ETact. Again check on the water savings.

Strategies to reduce water stress and yield reductions are:

- Fill the soil profile up to field capacity over the maximum root depth + some 20 - 30 cm for capillary rise. This should be done prior to sowing or at the initial stage when water availability is still relatively high and crop water requirements relatively low.
- Make the irrigation interval as long as possible, even inducing slight water stress as this enhances root development by the young plant looking for water ("growing after the water"). To enhance rapid and deep root growth a water deficit during the early growth periods can be advantageous for some crops (e.g. maize).
- For some crops, the sensitivity to water stress during a sensitive period is less pronounced when water deficit has been experienced during a preceding period (for instance maize, which is less sensitive to water stress during flowering when water stress has been experienced during the vegetative period).

Methods of dealing with scarce water supply at block or scheme level, such as crop selection, change of planting date, selection of drought resistant varieties, staggered sowing/planting and fixation of water allowances per individual block are other strategies.

6.3.5 Models as tools for evaluation of irrigation schedules

Several models are available under different conditions to help in irrigation scheduling. An example of such models is IRSIS (Irrigation Scheduling Information System). IRSIS is a computer programme that has been developed to assist scheme managers, irrigation advisers, consulting engineers, lecturers and students alike in problems concerning irrigation scheduling at field level (Raes *et al.*, 1988). For a given climate, crop and field it offers the following possibilities:

- Calculation of the net irrigation requirements;
- Calculation of the optimal water distribution resulting in the highest yield under conditions of limited water;
- Calculation of the yield response under rainfed agriculture;
- Planning of irrigation schedules for different operational conditions;
- Evaluation of a past irrigation schedule using historical data; and
- Forecasting irrigation actions during the operational stage according to forecasted weather information.

IRSIS shows the consequences of the calculated irrigation schedule in terms of water application efficiency and yield response.

6.4 Scheduling criteria under IRSIS

In IRSIS, irrigation schedules are generated by means of scheduling criteria i.e. `timing' and `depth' criteria. The `timing' criterion determines when irrigation has to be generated and the `depth' criterion determines the depth of the corresponding irrigation.

Five different `timing' criteria can be selected to generate irrigation:

(i) Fixed interval: Irrigation is applied at predetermined intervals. The decision to irrigate is taken independently of the water content in the rootzone. This option is particularly relevant for practical scheduling where simple operational criteria are required.

(ii) Allowable depletion amount: irrigation is applied whenever a predetermined amount of water below field capacity is depleted in the rootzone. This option is useful in the case of high frequency irrigation systems e.g. drip irrigation.

(iii) Allowable daily stress: Irrigation is applied whenever the actual evapotranspiration (E_{tact}) drops below a predetermined fraction of the potential evapotranspiration rate (E_{tcrop}). This option is relevant for suboptimal irrigation when the water supply is limited.

(iv) Allowable daily yield reduction: Irrigation is applied whenever the actual yield response (Y_{act}) drops below a predetermined fraction of the maximum yield (Ym.). An estimate of the daily Y_{act}/Y_{max} ratio is determined by the E_{tact}/ET_{crop} ratio and the yield response factor.

(v) Allowable fraction of the readily available water (RAW): Irrigation is applied whenever the soil water depletion, relative to RAW, drops below a predetermined level. This option is applied among others for optimal scheduling where up to 100% RAW irrigation is always secured before conditions of soil moisture stress (yield threshold level) occur.

Two different `depth' criteria can be selected:

(i) Back to field capacity: The soil water content in the rootzone is brought back to field capacity (plus or minus a specified depth depending on whether over- or under-irrigation is considered).

(ii) Fixed depth: A predetermined amount is applied.

Apart from generating irrigations by means of a `timing' and `depth' criterion, two other scheduling criteria can be selected in IRSIS:

(i) No irrigation required (Rainfed agriculture): No irrigations will be generated and the rootzone will gain water through rainfall only.

(ii) Manual irrigation scheduling: The actual timing and depth of each irrigation is specified manually.

6.5 PT Model in relation to irrigation scheduling

PARCHED THIRST is an acronym for Predicting Arable Resource Capture in Hostile Environment During The Harvesting of Incident Rainfall in Semi Arid Tropics. The model was developed to simulate the rainwater harvesting system in semi arid tropics. It simulates the runoff process, soil-water movement and the crop growth and yield in response to daily climatic data. It is a process-based model with a user-friendly interface. PARCHED-THIRST (PT) is a lumped parameter model where the landscape is divided into units of land assumed to be homogeneous landscape; this is referred to as profile in the model. The collection of these profiles forms a system, which can either, be rainfed or rainwater harvesting depending on the number of profiles. Rainwater harvesting system is represented by more than one profile where one or more profiles represent the runoff generation areas and the other represent the runoff receiving area and the only transferable mass between these profiles is the surface runoff.

At the system level the inputs to the model are weather variables, which include weather data, intensity data and disaggregation parameters. Other inputs at the system level include location and latitude, where the later is used in Penman equation to estimate evaporation. Criteria for sowing (timing) are entered at the system level, these can be user defined or predicted by model. In case of user defined, the input is the date of sowing for a particular season. Predicted sowing date is estimated based on the available soil water required for planting, number of rainy days before planting, the earliest date of which the season is expected to begin and maximum number of days that the model can wait before deciding it is time for sowing. The number of years of simulation is entered at the system level together with start date of the season and number of seasons to be simulated.

The inputs at the profile level are crops, weeds, soil properties and soil surface characteristics. Crop parameters required are plant population density (number of crop stands per hectare), crop cultivar and water logging. Crops that can be simulated by the model are limited to cereal crops such as maize, millet, sorghum and rice cultivars. The parameters for crop cultivar, which are inbuilt in the model, are length of growing stages in thermal time, growth rates of leaves at different growth stages, maximum root depth, daily root extension rates, grain number conversion factor and maximum grain weight. Temperature inbuilt inputs for crop are base and maximum temperatures, temperature plateau, and start of thermal denaturation. Other crop parameters inbuilt for a specific crop cultivar are light extension coefficient and plant permanent wilting point.

Weed parameters include, time of weeding operations which is number of days after crop emergence, maximum rate of water uptake by weeds, rate of root advancement and maximum root depth. Soil properties inputs to the model include soil layer depth and initial soil moisture content for each layer, soil type (texture), soil fertility equilibrium rate, soil strength which determines the resistance of soil to root growth, soil drainage parameter which determines rate at which water drains out of the soil profile and macro pores distribution and flow rate. Soil surface inputs parameters are bund height if storage is allowed, percentage of soil evaporation reduction if there is any surface treatment like crop cover, and mulching, area represented by the profile and slope of the profile.

The PT model is capable of simulating crop yield based on the daily input weather data. Of these inputs, rainfall is the most important. If daily rainfall recorded is the only input, this can be referred to as the rainfed system. However, supplementary irrigation can also be simulated by the model. This can be achieved by adding the excess water into the weather files. The modified file can be used to run the irrigation system. The aim of this practical is to use PT model in studying the water productivity under irrigation. Water productivity can be evaluated based on the eight scenarios, which are:

- Case 1: Extra fixed amount of water added at a fixed interval (50 mm at the interval of 10 days)
- Case 2: Extra fixed amount of water added at different intervals (50mm added at 10 irregular intervals)
- Case 3: Extra water added (amount not fixed) at fixed interval (10 days).

For the case 1 to 3, The total amount of water added was 500mm. The amount and timing are shown in Table 6.2 below.

For the other five scenarios, the seasonal amount of water added is varied at 300, 400, 500, 600 and 700 mm at the fixed interval while the amount is varying at different crop growth stages as shown in Figure 6.6. Case 9 is irrigation under ideal situation, where the timing and amount of water was calculated based on the ET_{crop} and K_c. The amount and timing is as shown in Figure 6.7.

Table 6.2. The amount and timing of added irrigation water. (Date in Julian days, starting from January 1)

DoY	153	158	164	170	175	182	186	190	197	205	208	219	221	230	235	241	245	251	Total
Case 1	50		50		50		50		50		50	50		50		50		50	500
Case 2	50	50	50	50		50		50		50			50		50		50		500
Case 3	100		50		40		45		35		30	35		50		70		45	500

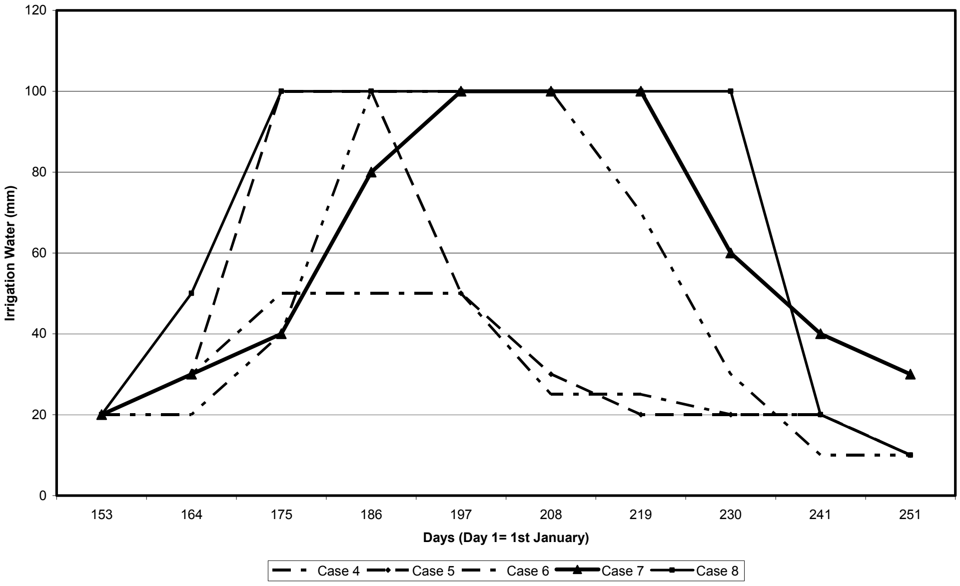

Figure 6.6. Cases 4 to 8 different irrigation timing and applied amount

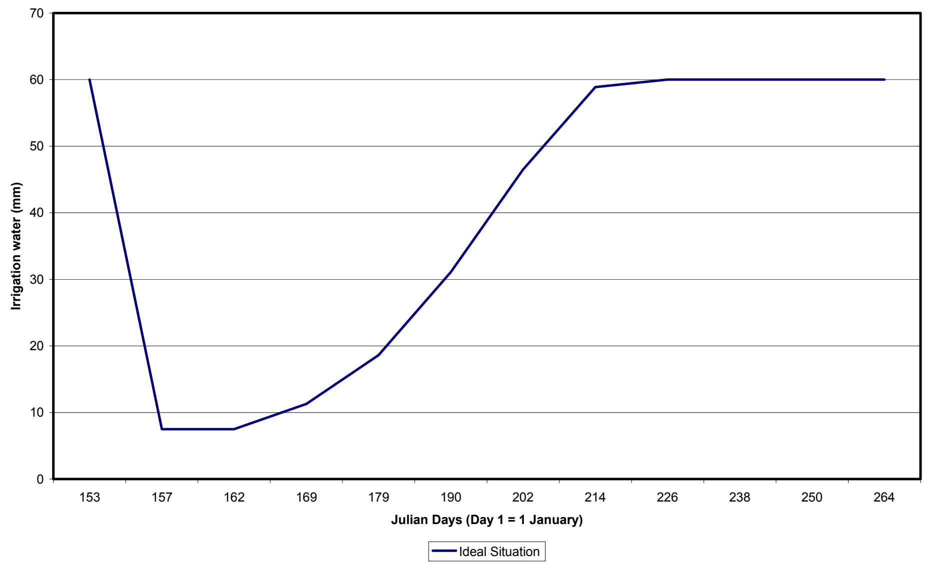

Figure 6.7. Cases 9 different irrigation timing and applied amount under ideal situation

6.6 Exercises

You will run eight exercises (1 to 8). During the exercise you will be required to fill in the following Table 6.3. The results can be obtained from simulation output summary, or from the output files. Then you will be required to calculate the water productivity, using the following formula:

$$Water\ Productivity(kg/.mm) = \frac{1000 \times Yield(t/ha) \times Area(ha)}{Seasonal\ Rain\,fall(mm)} \qquad (9)$$

Table 6.3: Results

Case	Parameter	2000	2001	2002
Case 1: Fixed Amount, Fixed Interval	Yield (t/ha)			
	Seasonal Rainfall (mm)			
	Productivity (kg/mm)			
Case 2: Fixed Amount, Variable Interval	Yield (t/ha)			
	Seasonal Rainfall (mm)			
	Productivity (kg/mm)			
Case 3: Variable Amount, Variable Interval	Yield (t/ha)			
	Seasonal Rainfall (mm)			
	Productivity(kg/mm)			
Case 4 - Case 9	Yield (t/ha)			
	Seasonal Rainfall (mm)			
	Productivity (kg/mm)			

6.6.1 Exercise 1: Irrigation at Fixed Amount and Interval

Extra fixed amount of water added at a fixed interval (50 mm at the interval of 10 days).

- Start PTv2.3 as experienced user
- Open IgurusiFixedBoth system
- Enter the system properties as shown in Figure 6.8
- Location of Weather data is c://IgurusiWeather/FixedBoth/IGURW00
- Save the system properties after making all the changes and replace IgurusiFixedBoth
- Click Run
- The model will ask you if you wish to see runtime graphics during the simulation? Click yes. You will be able to see the output as shown in Figure 6.9

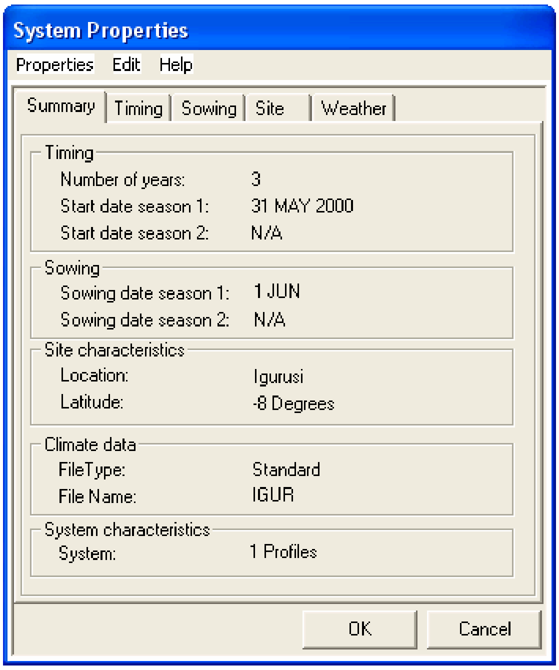

Figure 6.8. Summary of the system properties

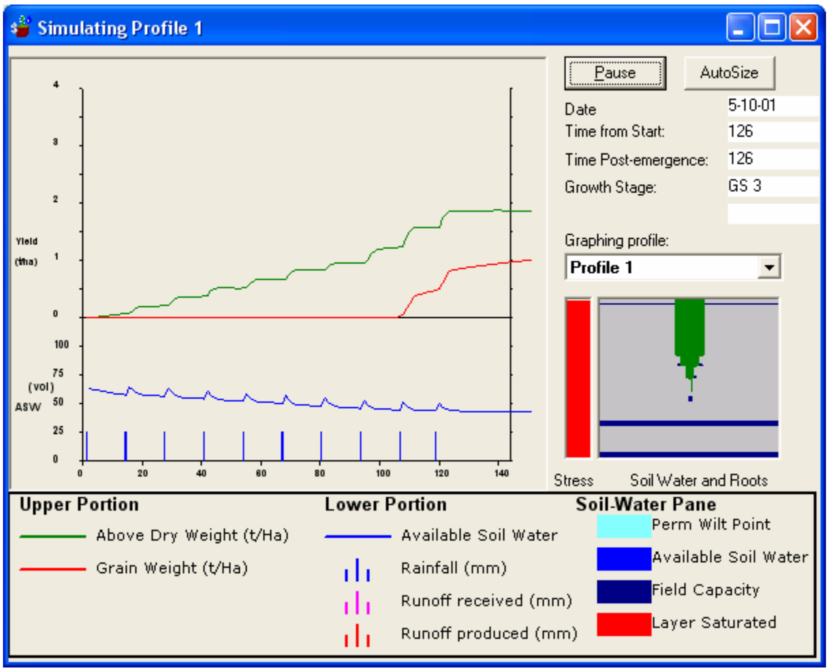

Figure 6.9. Runtime simulation graphics (year 2, Fixed amount at fixed interval)

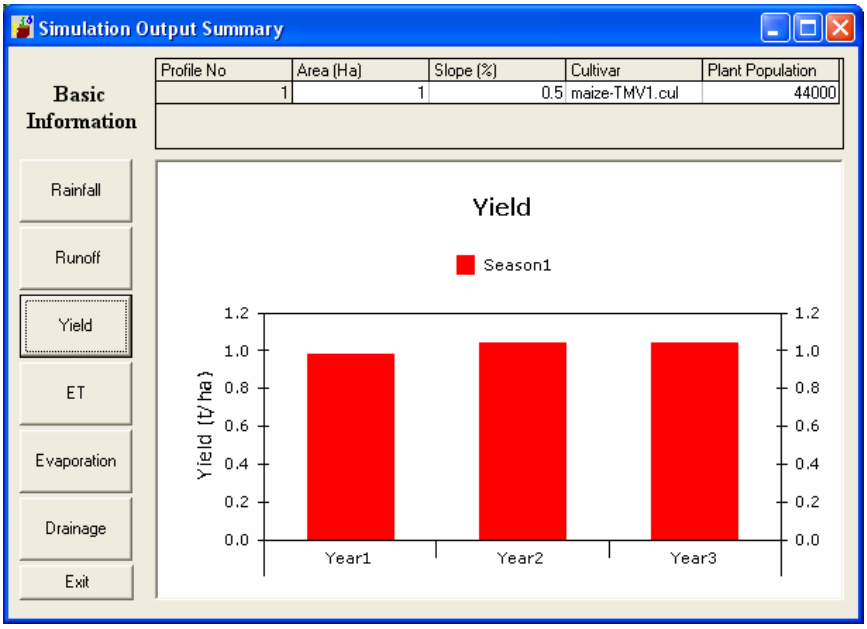

Figure 6.10. Maize yield (t/ha) for three years under irrigation (fixed amount and fixed interval)

6.6.2 Exercise 2: Irrigation at Fixed Amount Different Intervals

Extra fixed amount of water added at different intervals (50mm added at 10 irregular intervals).

- Start PTv2.3 as experienced user
- Open IgurusiFixedAmount system
- Enter the system properties as shown in Figure 6.8
- Location of Weather data is c://IgurusiWeather/FixedAmount/IGURW00
- Save the system properties after making all the changes and replace IgurusiFixedAmount
- Click Run
- The model will ask you if you wish to see runtime graphics during the simulation? Click yes. You will be able to see the output as shown in Figure 6.11
- At the end of simulation you will be able to see the Simulation Summary output. On clicking the Yield button, the yield summary graph will be displayed as shown in Figure 6.12.

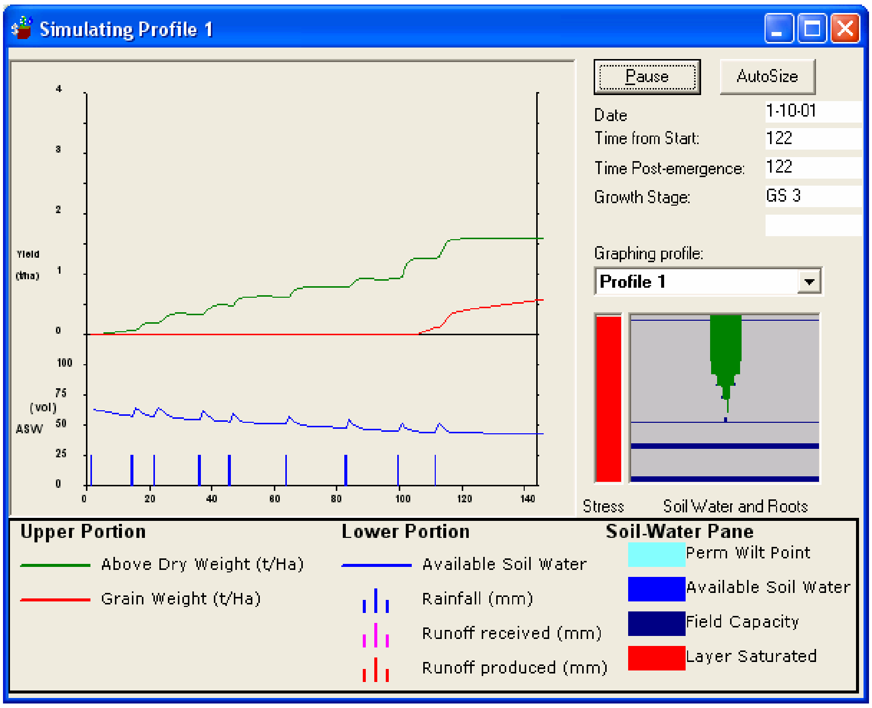

Figure 6.11. Runtime simulation graphics (year 2, Fixed amount at variable interval)

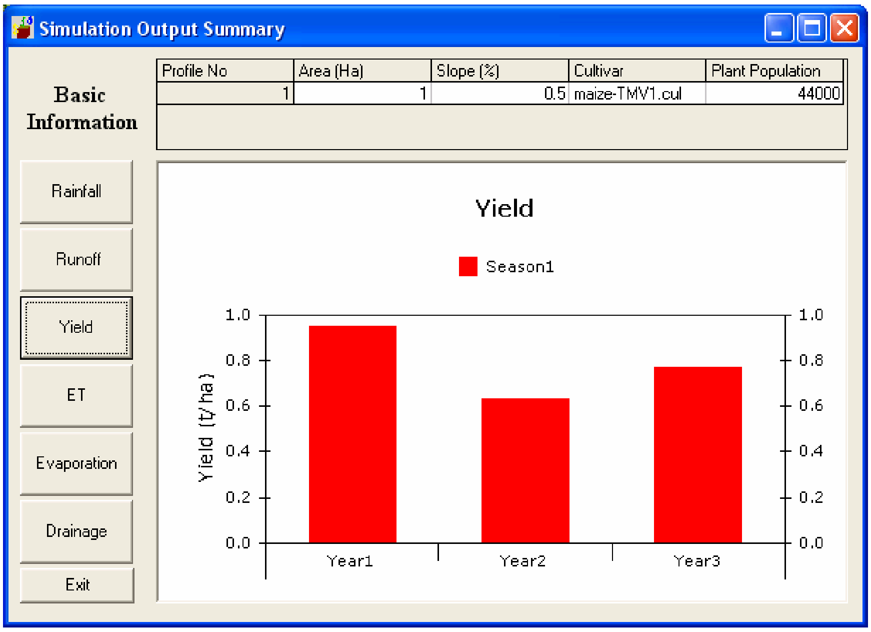

Figure 6.12. Maize yield (t/ha) for three years under irrigation (fixed amount and variable interval)

6.6.3 Exercise 3: Irrigation at Variable Amount Fixed Interval

Extra water added (not fixed amount) at fixed interval.

- Start PTv2.3 as experienced user.
- Open IgurusiFixedInterval system.
- Enter the system properties as shown in Figure 6.18.
- Location of Weather data is c://IgurusiWeather/FixedIntervalt/IGURW00.

- Save the system properties after making all the changes and replace .IgurusiFixedInterval.
- Click Run.
- The model will ask you if you wish to see runtime graphics during the simulation? Click Yes. You will be able to see the output as shown in Figure 6.13.
- At the end of simulation you will be able to see the Simulation Summary output. On clicking the Yield button, the yield summary graph will be displayed as shown in Figure 6.14.

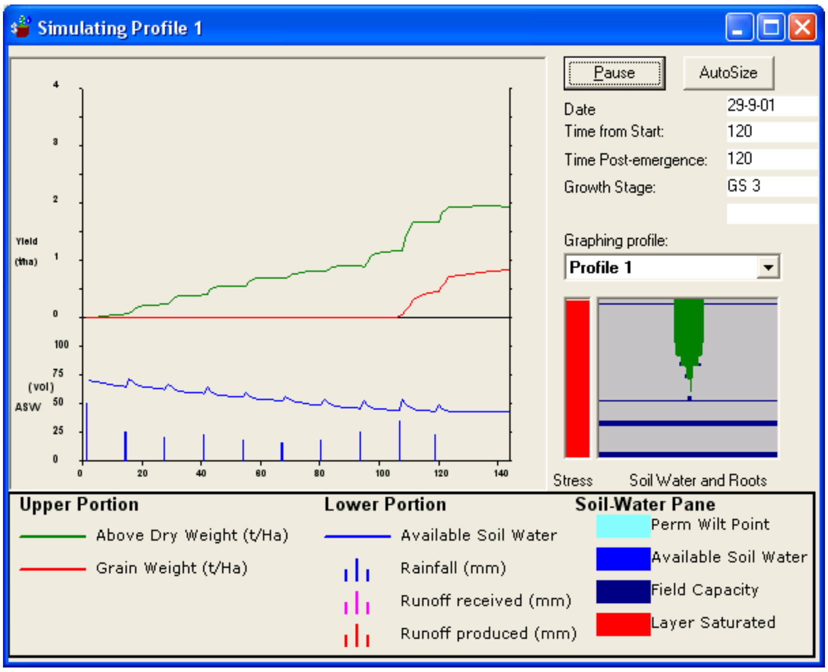

Figure 6.13. Runtime simulation graphics (year 2, Variable amount at fixed interval)

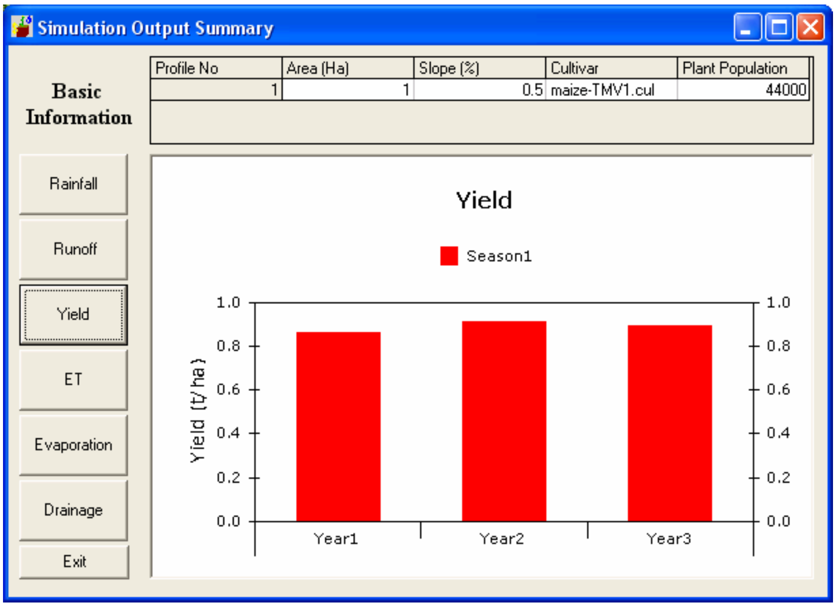

Figure 6.14. Maize yield (t/ha) for three years under irrigation (variable amount and fixed interval)

6.6.4 Exercise 4: Irrigation at Fixed Amount (300 mm) Fixed Interval

300 mm of irrigation water applied at fixed interval.

- Start PTv2.3 as experienced user
- Open IgurusiCase4 system
- Enter the system properties as shown in Figure 6.8
- Location of Weather data is c://IgurusiWeather/Case4/IGURW00
- Save the system properties after making all the changes and replace IgurusiCase4
- Click Run
- The model will ask you if you wish to see runtime graphics during the simulation? Click yes. You will be able to see the output as shown in Figure 6.15.
- At the end of simulation you will be able to see the Simulation Summary output.

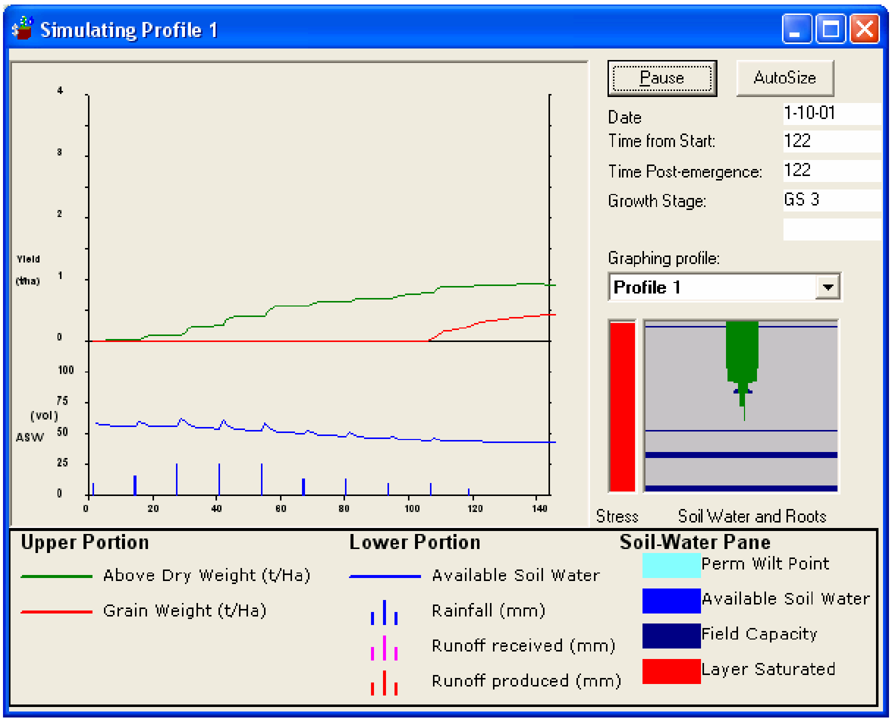

Figure 6.15. Runtime simulation graphics (year 2, Variable amount at fixed interval, 300 mm)

6.6.5 Exercise 5: Irrigation at Fixed Amount (400 mm) at Fixed Interval

400 mm of irrigation water applied at fixed interval.

- Start PTv2.3 as experienced user
- Open IgurusiCase5 system
- Enter the system properties as shown in Figure 6.8
- Location of Weather data is c://IgurusiWeather/Case5/IGURW00
- Save the system properties after making all the changes and replace IgurusiCase5
- Click Run
- The model will ask you if you wish to see runtime graphics during the simulation? Click yes. You will be able to see the output as shown in Figure 6.16.
- At the end of simulation you will be able to see the Simulation Summary output.

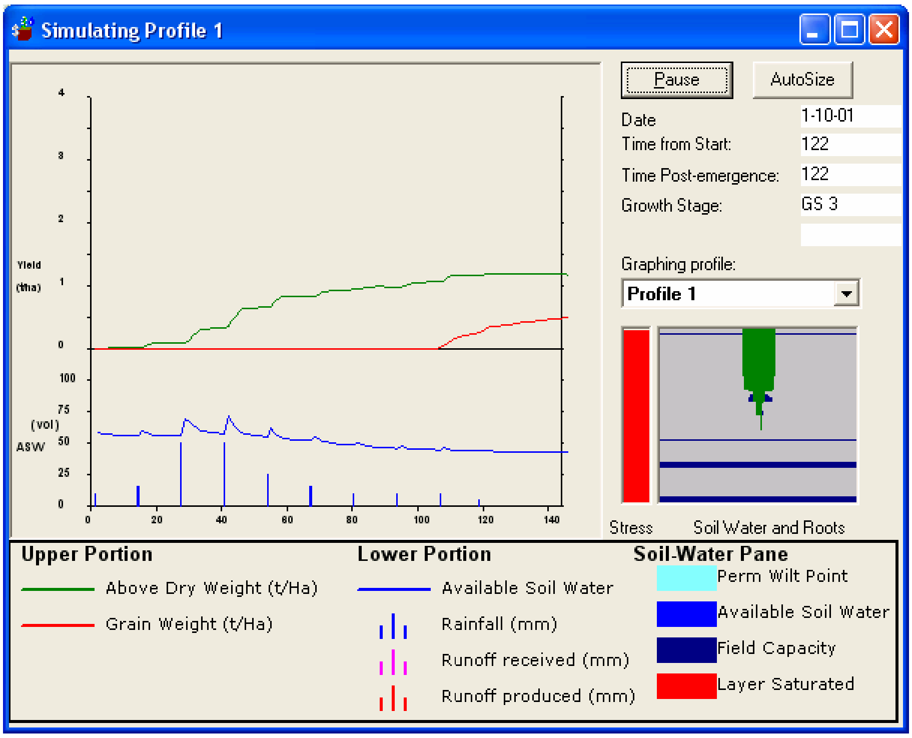

Figure 6.16. Runtime simulation graphics (year 2, Variable amount at fixed interval, 400 mm))

6.6.6 Exercise 6: Irrigation at Fixed Amount (500 mm) Fixed Interval

500 mm of irrigation water applied at fixed interval.

- Start PTv2.3 as experienced user
- Open IgurusiCase6 system
- Enter the system properties as shown in Figure 6.8.
- Location of Weather data is c://IgurusiWeather/Case6/IGURW00
- Save the system properties after making all the changes and replace IgurusiCase6
- Click Run
- The model will ask you if you wish to see runtime graphics during the simulation. Click yes. You will be able to see the output as shown in Figure 6.17.
- At the end of simulation you will be able to see the Simulation Summary output.

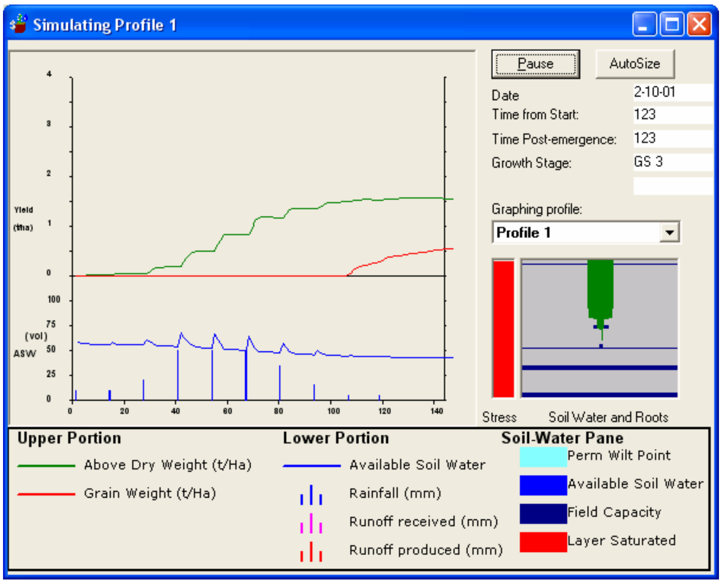

Figure 6.17. Runtime simulation graphics (year 2, Variable amount at fixed interval, 500 mm)

6.6.7 Exercise 7: Irrigation at Fixed Amount (600 mm) Fixed Interval

600mm of irrigation water applied at fixed interval.

- Start PTv2.3 as experienced user
- Open IgurusiCase6 system
- Enter the system properties as shown in Figure 6.8.
- Location of Weather data is c://IgurusiWeather/Case7/IGURW00
- Save the system properties after making all the changes and replace IgurusiCase6
- Click Run
- The model will ask you if you wish to see runtime graphics during the simulation? Click yes. You will be able to see the output as shown in Figure 6.18.
- At the end of simulation you will be able to see the Simulation Summary output.

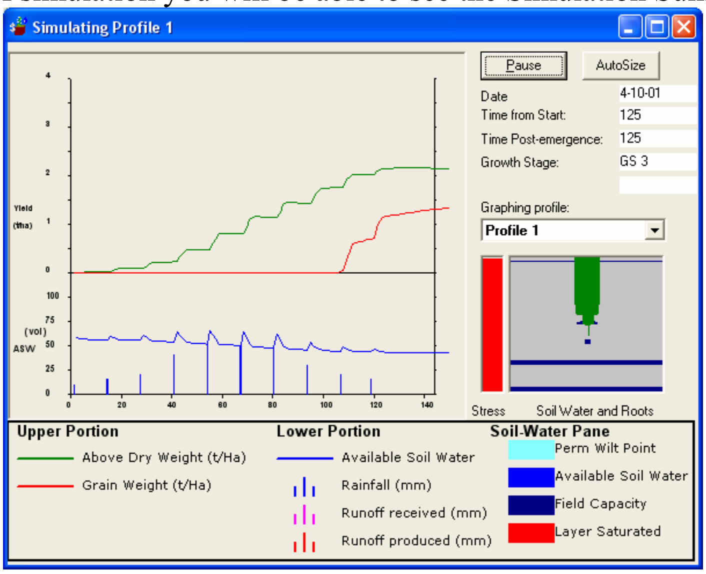

Figure 6.18. Runtime simulation graphics (year 2, Variable amount at fixed interval, 600 mm)

6.6.8 Exercise 8: Irrigation at Fixed Amount (700 mm) Fixed Interval

700 mm of irrigation water applied at fixed interval.

- Start PTv2.3 as experienced user
- Open IgurusiCase7 system
- Enter the system properties as shown in Figure 6.8.
- Location of Weather data is c://IgurusiWeather/Case8/IGURW00
- Save the system properties after making all the changes and replace IgurusiCase7
- Click Run
- The model will ask you if you wish to see runtime graphics during the simulation? Click yes. You will be able to see the output as shown in Figure 6.19. At the end of simulation you will be able to see the Simulation Summary output.

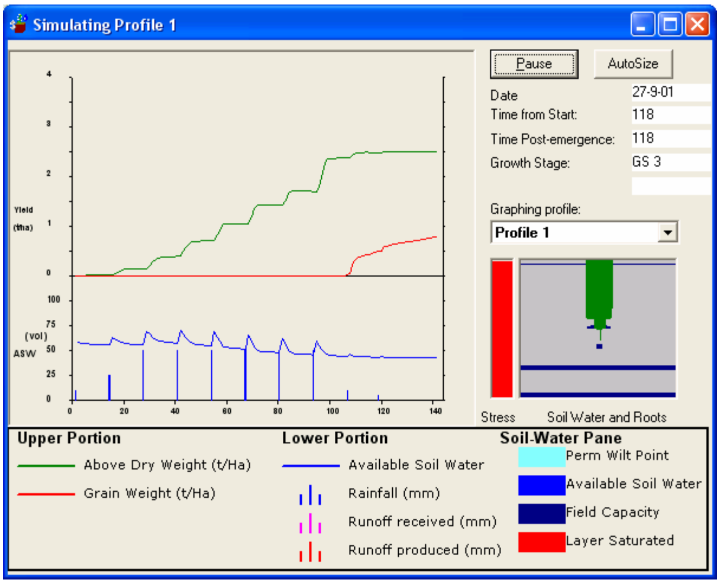

Figure 6.19. Runtime simulation graphics (year 2, Variable amount at fixed interval, 700 mm)

6.6.9 Exercise 9: Irrigation at Fixed Amount (428.9 mm) Fixed Interval

428.9 mm of irrigation water applied at ideal situation

- Start PTv2.3 as experienced user
- Open IgurusiIdealSituation system
- Enter the system properties as shown in Figure 6.8.
- Location of Weather data is c://IgurusiWeather/IdealSituation/IGURW00
- Save the system properties after making all the changes and replace IgurusiIdealSituation
- Click Run
- The model will ask you if you wish to see runtime graphics during the simulation? Click yes. You will be able to see the output as shown in Figure 6.20.
- At the end of simulation you will be able to see the Simulation Summary output.

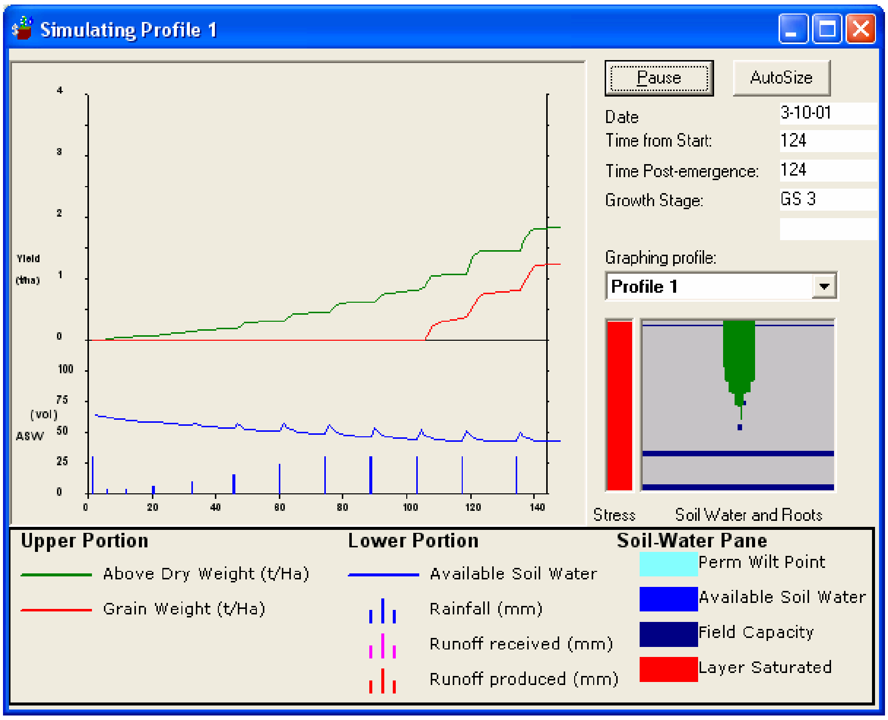

Figure 6.20. Runtime simulation graphics (year 2, Ideal Situation, 428.9 mm)

6.7 Expected Results

Table 6.4: Case 1 – Case 3

Case	Parameter	2000	2001	2002
Rainfed	Yield (t/ha)	0.02	0.35	0.37
	Seasonal Rainfall (mm)	20.6	0	0
	Productivity (kg/mm)	0.97	-	-
Case 1: Fixed Amount, Fixed Interval	Yield (t/ha)	0.98	1.04	1.04
	Seasonal Rainfall (mm)	520.6	500	500
	Productivity (kg/mm)	1.89	2.08	2.08
Case 2: Fixed Amount, Variable Interval	Yield (t/ha)	0.95	0.63	0.77
	Seasonal Rainfall (mm)	520.6	450	450
	Productivity(kg/mm)	1.82	1.40	1.71
Case 3: Variable Amount, Variable Interval	Yield (t/ha)	0.86	0.91	0.89
	Seasonal Rainfall (mm)	520.6	500	460
	Productivity (kg/mm)	1.65	1.82	1.93

Table 6.5: Case 4 to Case 9

Case	Parameter	2000	2001	2002
Case 4	Yield (t/ha)	0.45	0.5	0.5
	Seasonal Rainfall (mm)	300	300	300
	Productivity (kg/mm)	1.5	1.7	1.7
Case 5	Yield (t/ha)	0.54	0.55	0.6
	Seasonal Rainfall (mm)	400	400	400
	Productivity (kg/mm)	1.4	1.4	1.5
Case 6	Yield (t/ha)	0.6	0.6	0.7
	Seasonal Rainfall (mm)	500	500	500
	Productivity (kg/mm)	1.2	1.2	1.4
Case 7	Yield (t/ha)	1.4	1.4	1.4
	Seasonal Rainfall (mm)	600	600	600
	Productivity (kg/mm)	2.3	2.3	2.3
Case 8	Yield (t/ha)	0.8	0.9	1
	Seasonal Rainfall (mm)	700	700	700
	Productivity (kg/mm)	1.1	1.3	1.4
Ideal Situation (481mm)	Yield (t/ha)	1.46	1.28	1.78
	Seasonal Rainfall (mm)	502	481.4	481.4
	Productivity (kg/mm)	2.9	2.7	3.7
Ideal Situation (421mm)	Yield (t/ha)	1.07	0.9	1.29
	Seasonal Rainfall (mm)	442	421.4	421.4
	Productivity (kg/mm)	2.4	2.1	3.1

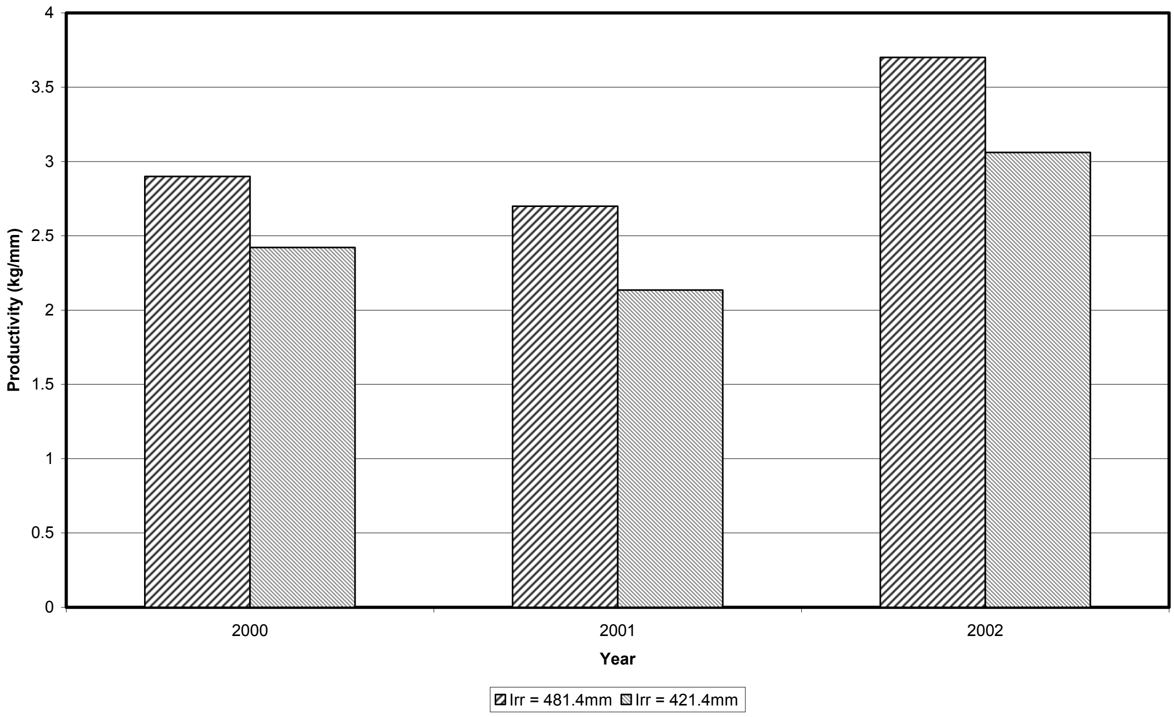

Figure 6.21. Comparison of productivity by missing out last irrigation of 60 mm

6.8 References

Kihupi, N.I. (2000), *Water Requirements for Crop Production - A Teaching Manual,* Morogoro

Mzirai, O.B.,T. Bwana, S.D. Tumbo, F.B. Rwehumbiza and H.F. Mahoo (2004), *PARCHED THIRST HANDBOOK*, SWMRG – PT Help Office