08. WATER BUDGETING AND ITS IMPORTANCE - IRRIGATION SCHEDULING - APPROACHES

Water budgeting:

Allocation of the water receipt including anticipated within the crop period and its detailed account of expenditure for efficient and profitable farm management is called as water budgeting.

Water budgeting may be for an irrigation system planned by irrigation engineers; may be for a canal or for an area (block) or may be for a farm according to the need and plan by responsible persons who plan the irrigation efficiency.

Importance of water budgeting:

- Efficient utilization of available recourse (water) for bringing more area under irrigation.
- To increase the productivity of a region / farm.
- To increase cropping intensity of a region / farm
- To tide over some dry-spells
- To reduce excess irrigation and losses caused thereby
- To avoid run off losses

Irrigation scheduling

Irrigation scheduling is defined as frequency with which water is to be applied based on needs of the crop and nature of the soil.

Irrigation scheduling is nothing but number of irrigations and their frequency required to meet the crop water requirement.

Irrigation scheduling may be defined as scientific management techniques of allocating irrigation water based on the individual crop water requirement (ETc) under different soil and climatic condition, with an aim to achieve maximum crop production per unit of water applied over a unit area in unit time.

Based on the above definition, the concept made is.

"If we provide irrigation facility the agricultural production and productivity will go up automatically"

Irrigation scheduling is a decision making process repeated many times in each year involving when to irrigate and how much of water to apply? Both criteria influence the quantity and quality of the crop. It indicates how much of irrigation water to be used and how often it has to be given.

Effect of application of right amount and excess amount of water

Excess irrigation is harmful because

a) It wastes water below root zone
b) It results in loss of fertilizer nutrients
c) It causes water stagnation and salinity
d) It causes poor aeration
e) Ultimately it damages the crops

However, Irrigation scheduling has its own meaning and importance according to the nature of the work.

For irrigation Engineers

Irrigation scheduling is important to cover more area with available quantity of water or to satisfy the whole command from head to tail reach in the canal or river system.

For soil scientists

It is important that the field should not be over irrigated or under irrigated as both will spoil the chemical and physical equilibrium of the soil.

For Agronomists

It is very much important to get higher yield per unit quantity of water in normal situations and to protect the crop to get as much as possible yield under drought situation by means on supplying water in optimum ratio and minimizing all field losses.

Importance of irrigation scheduling

How much and how often water has to be given depends on the irrigation requirement of the crop.

Irrigation requirement (IR) = Crop water requirement (CWR) – Effective rainfall (ERF)

It can be expressed either in mm/day/ or mm/month

If the crop water requirement of a particular crop is 6 mm per day, it means every day we have to give 6 mm of water to the crop. Practically it is not possible since it is time consuming and laborious. Hence, it is necessary to schedule the water supply by means of some time intervals and quantity. For example the water requirement of 6 mm/ day can be scheduled as 24 mm/for every 4 days or 30 mm/for every 5 days or 36 mm/for every 6 days depending upon the soil type and climatic conditions prevailing in that particular place. While doing so we must be very cautions that the interval should not allow the crop to suffer for want of water.

Practical considerations in irrigation scheduling

Before scheduling irrigation in a farm or field or a command, the following criteria should be taken care for efficient scheduling

1. Crop factors

a) Sensitiveness to water shortage
b) Critical stages of the crop
c) Rooting depth
d) Economic value of the crop

2. Water delivery system

a) Canal irrigation or tank irrigation (It is a public distribution system where scheduling is arranged based on the decision made by public based on the resource availability).
b) Well irrigation (individual decision is final)

3. Types of soil

a) Sandy – needs short frequency of irrigation and less quantity of water
b) Clay – needs long frequency of irrigation and more quantity of water

4. Salinity hazard

To maintain favorable salt balance, excess water application may be required rather than ET requirement of the crop to leach the excess salt through deep percolation

5. Irrigation methods

a) Basin method allows more infiltration through more wetting surface which in turn needs more water and long interval in irrigation frequency
b) Furrow method allows less infiltration due to less wetting surface which needs less water and short interval in irrigation frequency.
c) Sprinkler method needs less water and more frequency
d) Drip method needs less water and more frequency

6. Irrigation interval

The extension of irrigation interval does not always save water. The interval has to be optimized based on the agroclimatic situation.

7. Minimum spreadable depth

We cannot reduce the depth based on the water requirement of the crop alone. The depth should be fixed based on the soil type, rooting nature of the crop and irrigation method followed. The minimum depth should be so as to achieve uniformity of application and to get uniform distribution over the entire field.

Theoretical approaches of irrigation scheduling

I Direct approach

a) Depth interval and yield approach
b) Soil moisture deficit and optimum moisture regime approach
c) Sensitive crop approach
d) Plant observation method

II Indirect or predictive approach

a) Critical stage or Phenological stage approach

b) Meteorological or climatological approach

III Mathematical approach

a) Estimation method approach
b) Simple calculation method

IV system as a whole approach

a) Rotational water supply schedule

I. Direct approach

A) Depth interval and yield approach

In this method, different depths of irrigation water at different time intervals fixed arbitrarily are tried without considering the soil and weather characters.

The irrigation treatment which gives the maximum yield with minimum depth and extended interval is chosen as the best irrigation schedule. Earlier workers have adopted this practice to work out the duty of water for different crops in many irrigation projects. It is the rough irrigation schedule. Hence may irrigation projects which have adopted this practice have failed to achieve the full efficiency?

Disadvantages

- ❖ Rainfall is not taken into account
- ❖ Ground water contribution is not taken into account
- ❖ Soil parameters are not taken for calculating irrigation requirement and hence this approach is not in use.

B) Soil moisture deficit and optimum moisture regime approach

This approach considers soil moisture content in the root zone of the crop for fixing the schedule. When the soil moisture reaches a pre fixed value, may be 40% of Available Soil Moisture (ASM) or 50% ASM or 60% ASM, irrigation is given. The degree of depletion is measured through percentage of availability by using gravimetric, tensiometer, resistance block, neutron probe, etc.,

Disadvantages

- Soil moisture alone is taken into account
- Hence it cannot be taken for all type of soil in particular region
- It varies from soil to soil

C) Sensitive crop approach

The crops which are grown for their fresh leaves or fruits are more sensitive to water shortage than the crops which are grown for their dry seeds or fruits. Based on their sensitivity the crops can be indexed as below.

Sensitivity

Low	Low to Medium	Medium to high	High
Cassava	Alfalfa	Beans	Banana
Millets	Cotton	Citrus	Cabbage
Redgram	Maize	Soybean	Fresh Green
	Groundnut	Wheat	Vegetables
			Rice
			Sugarcane
			Tomato

D) Plant observation method

Normally in field condition farmers use to adopt this practice for scheduling irrigation. The day to day changes in plant physical character like colour of the plant, erect nature of plant leaves, wilting symptoms, etc., are closely and carefully observed on the whole and not for individual plant and then time of irrigation is fixed according to the crop symptoms. It needs more skill and experience about the crop as well as local circumstances like field condition, the rainy days of that tract etc.,

Disadvantage

- No accuracy in finding the crop water need

- Sometimes sensitive symptoms are evident only after reaching almost the wilting point. So yield loss will occur.

i) Indicator plant technique

As we have seen already some crops like sunflower, tomato are highly sensitive to water stress which will show stress symptom earlier than other stress tolerating crops. Hence, to know the stress symptoms earlier such sensitive crops are planted in random in the field and based on the stress symptoms noticed in such plants, scheduling of irrigation can be made. This technique is called indicator plant technique.

ii) Micro plot technique or indicator plot technique

In this method a one cubic foot micro plot is made of with coarse textured soil to have more infiltration less water holding capacity and more evaporation than the actual main field. Normally the field soil is mixed with sand in 1:2 ratio and filled in the micro plots made in the field. The seed of the same crop and variety is grown in micro plot with all similar cultural practices as that of the main crop. The crops in micro plot show early stress symptoms than that of main field. Based on this scheduling of irrigation can be made.

II Predictive approach of indirect approach

A) Critical stage or phonological stage approach

The growth period of an annual crop can be divided into four growth stages

Initial stage	: from sowing to 10% ground cover
Crop development stage	: 10 to 70% ground cover
Mid season stage	: flowering to grain setting stage
Late season stage	: ripening and harvesting stage

B) Meteorological approach

The basic principles employed with this approach are estimation of daily potential evapo-transpiration rates. Hence it requires knowledge on

a) Short term evapo-transpiration rates at various stages of plant development

b) Soil water retention characteristics

c) Permissible soil water deficit in respect to evaporative demand

d) Effective rooting depth of the crop grown

The irrigation scheduling is based on the cumulative pan evaporation and irrigation depth.

Irrigation at ratio of irrigation water (IW) and cumulative pan evaporation (CPE).

$$IW/CPE = \frac{\text{depth of water to be irrigated}}{\text{Cumulative pan evaporation for particular period}}$$

For example, for ten days cumulative pan evaporation at the rate of 10 mm per day equal to 100 mm (CPE). Irrigation depth to be given is 50 mm. Therefore IW/CPE ratio is

$$IW/CPE \quad \frac{\text{50 mm (depth)}}{\text{100 mm (CPE)}} = 0.5$$

Like this many ratio have to be tried and find the best yield performing rabi which can be adopted for scheduling irrigation.

The irrigation depth (IW) for different crops are fixed based on the soil and climatic condition. The ratio of IW / CPE which gives relatively best yield is fixed for each crop by experiment with different rations.

The irrigation depth (IW) divided by the ratio (R) will give the cumulative pan evaporation value at which irrigation is to be made.

For example the irrigation depth (IW) needed is 50 mm and the ratio (R) to be tried is 0.5.

Therefore the cumulative pan evaporation value needed to irrigated the field is

IW / R 50 / 0.5 = 100 mm

If the 100 mm of CPE is attained in 10 days (pan evaporation @ 10 mm per day), once in 10 days irrigation is to be given.

Advantages

Gives best correlation compared to other formulae where climatic parameters and soil parameters (depth) are considered.

Disadvantages

This approach is subject to marked influence by the selecting pan site.

For example

USWB class A open pan evaporimeter reading from June to December amounted to 130 cm when pan is sited on grass field, 150 cm when pan is sited on dry land with fetch of grass, 176 cm when pan is sited on dry land without fetch of grass

Pan readings generally over estimated ET during early stage and maturity stage

III Mathematical approach

A) Estimation method approach

It is nothing but scientific prediction mainly based on he climate and soil type. Calculated crop water need and estimated root depth are taken into account in this.

a. Soil type

Soil type are classified as follows

Sandy / shallow	-	Low depth of water and more frequency
Loamy soil	-	Moderate depth water and less frequency
Clay soil	-	More depth of water and less frequency

b. Climate

Climates are classified based on **reference ET** as follows:

Reference ET

4 – 5 mm/day – Low

6 – 7 mm/day – Medium

8 – 9 mm/day – High

Reference ET (mm/day) for different climatic zones

	Mean daily temp		
Climatic zone	15^0C Low	15 – 25^0C Medium	> 25^0C High
Desert/arid	4-6	7-8	9-10
Semiarid	4-5	6-7	8-9
Sub humid	3-4	5-6	7-8
Humid	1-2	3-4	5-6

The above table is based on the crop water needs during peak period. It is also assumed that there is no rainfall or little occurs during the growing season. Based on this method estimated irrigation schedule is given below for major field crops.

Estimated irrigation schedule for major field crops in peak periods

Intervals in days												
	Sandy				**Loamy**				**Clay**			
Climate	**1**	**2**	**3***	**Depth**	**1**	**2**	**3***	**Depth**	**1**	**2**	**3***	**Depth**
Banana	5	3	2	25	7	5	4	40	10	7	5	55
Cotton	9	6	5	40	11	8	6	55	14	10	7	70
Sorghum	8	6	4	40	11	8	6	55	14	10	7	70
G.nut	6	4	3	25	7	5	4	35	11	8	6	50
Maize	8	6	4	40	11	8	6	55	14	10	7	70
Peas	6	4	3	30	8	6	4	40	10	7	5	50
Soybean	8	6	4	40	11	8	6	55	14	10	7	70
Sugarcane	8	6	4	40	10	7	5	55	13	9	7	70
Sunflower	8	6	4	40	11	8	6	55	14	10	7	70
Wheat	8	6	4	40	11	8	6	55	14	10	7	70
Tomato	6	4	3	30	8	6	4	40	10	7	5	50

1* - Low temperature of 15^0C 2* - medium temperature of $15\text{-}25^0C$

3*- high temperature of $>25^0C$

Adjustment in this method for Non peak periods

a) In early growth stages

The irrigation could be adjusted with little water and same frequency. But same water and less frequency are not advisable.

b) In late growth stage

Less frequency with same amount of water is advisable in this period.

c) In rainy days

The table schedule is to be adjusted when there is contribution from rainfall during crop growth period. This can be adjusted by giving longer interval (high frequency) with little water.

d) For irrigation practice and soil characteristics

For example, if a maize crop is grown on a clayey soil in a moderately warm climate, according to the table the intervals is 10 days and the depth is 70 mm per application. But based on the irrigation method practiced and soil type, the soil is unable to hold 70mm of water per application. The soil could hold only 50 mm/application. In this situation instead of giving 70 mm for every 10 days, it is possible to give 63 mm for every 9 days or 56 mm for every 8 days or 49 mm for every 7 days or 42 mm for every 6 days. The 49 mm for every 7 days is the approximate interval for local situation. Hence this method of intervals for irrigation can be adopted.

B) Simple Calculation Method

It is based on the estimated depth of irrigation application and calculated irrigation need of the crop over growing season. Hence the influence of climate especially temperature and rainfall is taken for consideration. Hence, it is more accurate than that of the estimated method.

It involves four steps

a) Estimate the net and gross irrigation depth (d) in mm.

b) Calculate the irrigation water need (mm) over total growing season

c) Calculate the number of irrigation over total growing season

d) Calculate the irrigation interval

Estimation net and gross irrigation

The net irrigation depth is calculated based on the irrigation depth. This may vary with local irrigation method and practice and soil type. If local data are not available the table given below can be used which will be approximate for most of the field crops. The root depth can be measured locally and adjusted.

Approximate net irrigation depth (mm)

	Rooting depth		
Soil type	**Shallow**	**Medium**	**Deep**
Sandy	15	30	40
Loamy	20	40	60
Clay	30	50	70

Root depth of different field crops are Given below

Shallow 30 – 60 cm

Rice, rabi, onion, potato, pineapple, cabbage.

Medium 50 – 100 cm

Banana, bean, coconut, groundnut, peas, soybean, sunflower, tobacco, tomato, cumbu, pulses

Deep 90-150 cm

Citrus, grapes, wheat, cotton, maize, wheat, sorghum, soybean

We know very well that all the water applied in the field cannot be used by the plants. There is some water loss through deep percolation, run off etc., To include this unavoidable water loss the field application efficiency (eaf) can be used. The gross irrigation depth includes the water loss through deep percolation and run off.

100 x net irrigation depth

Gross irrigation (d) = -------------------------------

$$\text{Field application efficiency} = \frac{100 \times \text{n.d (cm)}}{\text{eaf (\%)}}$$

If reliable data for field application efficiency are not available the efficiency rate given below can be used which are more approximate.

For surface method = 60%

Sprinkler method = 75%

Drip method = 90%

According to the table, the depth is 40 mm for tomato grown on a loamy soil. If furrow irrigation is used, field application efficiency is 60% and therefore gross irrigation depth is

$$\text{Gross irrigation depth} \quad d = \frac{100 \times 40}{60} = 67 \text{ mm}$$

b) Calculation of irrigation water need for total growing season

Tomato crop is planted in February 7th and harvested in June 30th

Water needs mm/month

February	**March**	**April**	**May**	**June**	**Total**
67	110	166	195	180	718

The water need is calculated based of ET value of the crop during that period

c) Calculate the number of irrigation over total growing period

$$\text{Number of irrigation} = \frac{\text{Total water need}}{\text{Depth}}$$

$$= \frac{718}{} = 18$$

40

Duration (days)

d). Irrigation interval = ----------------------------

Number of irrigation

143

= ----- = 7.94 = 8.0

18

Conclusion

Irrigation schedule for tomato

Net d = 40 mm

Gross d = 65 mm

Interval = 8 days

Water requirement for peak season

April	May	June	Total
166	195	180	541

Depth (d) = 40 mm

WR = 541

Number of irrigation = -------------

d = 40

= 13.5 approximately 14 irrigations

Duration 91 days

Irrigation interval = ----------------------- = --------- = 6.5 days = 7.0

No. of irrigation 14

Water requirement for early growth period

February	March	Total
67	110	117

$$\text{No. of irrigation} = \frac{177}{40}$$

$= 4.4$

Approximately $= 4$ irrigation

$$\text{Irrigation interval} = \frac{52}{4} = 13 \text{ days interval}$$

This interval is too long and the rooting depth is also very shallow during this period. Hence adjustment can be made by reducing the irrigation depth as follows

i.e., instead of 40 mm depth 30 mm depth can be tried

$$\frac{177}{30} = 5.9 = 6 = \frac{52 \text{ days}}{6} = 8.67 = 9.0$$

9 days is irrigation interval can be adopted.

IV. System as a whole approach

A) Rotational water supply

R.W.S is one of the techniques in irrigation water distribution management. It aims at equi-distribution of irrigation water irrespective of location of the land in the command area by enforcing irrigation time schedules.

Each 10 ha block is divided into 3 to 4 sub units (irrigation groups) According to the availability of irrigation water, stabilized field channels and group-wise irrigation requirement, time schedules are evolved. The irrigation will be done strictly in accordance with the group-wise time schedules by the block committees. Within the group, the time is to be shared by the farmers themselves.