06. CROP WATER REQUIREMENT - POTENTIAL EVAPOTRANSPIRATION (PET) AND CONSUMPTIVE USE- FACTORS AFFECTING CROP WATER REQUIREMENT - CRITICAL STAGES – WATER REQUIREMENT OF DIFFERENT CROPS

Crop water Requirement

Crop water requirement is the water required by the plants for its survival, growth, development and to produce economic parts. This requirement is applied either naturally by precipitation or artificially by irrigation. Hence the crop water requirement includes all losses like:

a) Transpiration loss through leaves (T)

b) Evaporation loss through soil surface in cropped area (E)

c) Amount of weather used by plants (WP) for its metabolic activities which is estimated as less than 1% of the total water absorption. These three components cannot be separated so easily. Hence the ET loss is taken as crop water use or crop water consumptive use.

d) Other application losses are conveyance loss, percolation loss, runoff loss, etc., (WL).

e) The water required for special purposes (WSP) like puddling operation, ploughing operation, land preparation, leaching, requirement, for the purpose of weeding, for dissolving fertilizer and chemical, etc.

Hence the water requirement is symbolically represented as:

$$WR = T + E + WP + WL + WSP$$

(The other application losses and special purposes are mostly indented for wet land cultivation. Hence for irrigated dry land crop the ET loss alone is accounted for crop water requirement).

The estimations of the water requirement of crop are one of the basic needs for crop planning on the farm and for the planning of any irrigation project.

Water requirement may be defined as the quantity of water required by a crop or diversified pattern of crop in a given period of time for its normal growth under field conditions at a place.

Water requirement includes the losses due to ET or CU and losses during the application of irrigation water and the quantity of water required for special purposes or operations such as land preparation, transplanting, leaching etc., Hence it may be formulated as follows

WR = ET or Cu + application loss + water for special needs.

It can also be stated based on “Demand” and “supply source” as follows

WR = IR + ER + S

Where,

IR - Irrigation requirement

ER - Effective rainfall

S - Contribution from ground water table.

Hence the idea about crop water requirement is essential for farm planning with respect to total quantity of water needed and its efficient use for various cropping schemes of the farm or project area. This crop water requirement is also needed to decide the stream size and design the canal capacity.

The combined loss of evaporation and transpiration from a cropped field is termed as evapotranspiration which is otherwise known as consumptive use and denoted as ET and this is a part of water requirement.

CU = E + T + WP

Therefore,

WR = CU + WL + WSP

The crop water requirement can also be defined as water required meeting the evapotranspiration demand of the crop and special needs in case of wet land crop and which also includes other application losses both in the case of wet land and garden land crops. This is also known as crop water demand.

The crop water requirement varies from place to place, from crop to crop and depends on agro-ecological variation and crop characters. The following features which mainly influence the crop water requirement are:

1) Crop factors
    a) Variety
    b) Growth stages
    c) Duration
    d) Plant population
    e) Crop growing season
2) Soil factors
    a) Structure
    b) Texture
    c) Depth
    d) Topography
    e) Soil chemical composition
3) Climatic factors
    a) Temperature
    b) Sunshine hours
    c) Relative humidity
    d) Wind velocity
    e) Rainfall
4) Agronomic management factors

a) Irrigation methods used

b) Frequency of irrigation and its efficiency

c) Tillage and other cultural operations like weeding, mulching etc / intercropping etc

Based on al these factors, average crop water requirement for various crops have been worked out and given below for tropical conditions.

Irrigation requirement

The field irrigation requirement of crops refers to water requirement of crops exclusive of effective rainfall and contribution from soil profile and it may be given as follows

IR - WR – (ER + S)

IR - Irrigation requirement

WR - Water requirement

ER - Effective rainfall

S - Soil moisture contribution

Irrigation requirement depends upon the

a) Irrigation need of individual crop based on area of crop
b) Losses in the farm water distribution system etc.

All the quantities are usually expressed in terms of water depth per unit of land area (ha/cm) or unit of depth (cm).

Net irrigation requirement

It is the actual quantity of water required in terms of depth to bring the soil to field capacity level to meet the ET demand of the crop.

It is the water applied by irrigation alone in terms of depth to bring the field to field capacity level. To work out the net irrigation requirement, ground water contribution and other gains in soil moisture are to be excluded. It is the amount of irrigation water required to bring the soil moisture level in the effective root zone to field capacity, which in turn meet the ET effective root zone to field capacity, which in turn meet the ET demand of the crop. It is the difference between the F.C and the soil moisture content in the root zone before starting irrigation.

$$d = \sum_{i=i}^{n} \frac{Mfci - Mbi}{100} \times A_i \times D_i$$

d	=	Net irrigation water to be applied (cm)
Mfci	=	FC in i^{th} layer (%)
Mbi	=	Moisture content before irrigation in i^{th} layer (%)
Ai	=	Bulk density (g/cc)
Di	=	depth (cm)
n	=	number of soil layer

Gross irrigation requirement

The total quantity of water used for irrigation is termed gross irrigation requirement. It includes net irrigation requirement and losses in water application and other losses. The gross irrigation requirement can be determined for a field, for a farm, for an outlet command area, and for an irrigation project, depending on the need by considering the approximate losses at various stages of crop.

$$\text{Gross irrigation} = \frac{\text{Net irrigation requirement}}{\text{Field efficiency of system}} \times 100$$

Irrigation frequency

Irrigation frequency is the interval between two consecutive irrigations during crop periods. Irrigation frequency is the number of days between irrigation during crop periods without rainfall. It depends upon the rate of uptake of water by plants and soil moisture supply capacity to plant and soil moisture available in the root zone. Hence it is a function of crop, soil and climate. Normally, irrigation should be given at about 50 per cent and not over 60 per cent depletion of the available moisture from the effective root zone in which most of the roots are concentrated.

In designing irrigation system the irrigation frequency to be used, is the time (days) between two irrigation in the period of highest consumptive use of crop growth, i.e. peak consumptive use of crop.

Design frequency (days)

$$= \frac{\text{F C – moisture content of the root zone prior to starting irrigation}}{\text{Peak period consumptive use rate of crop}}$$

Irrigation period

Irrigation period is the number of days that can be allowed for applying one irrigation to a given design area during peak consumptive use period of the crop

Irrigation period

$$= \frac{\text{Net amount of moisture in soil at start of irrigation (FC-PWP)}}{}$$

Peak period consumptive use of the crop

Critical stages for irrigation:

The stage at which the water stress causes severe yield reduction is also known as **critical stage of water requirement**. It is also known as **moisture sensitive period**. Moisture stress due to restricted supply of water during the moisture sensitive period or critical stage will irrevocably reduce the yield. Provision of adequate water and fertilizer at other growth stage will not even help in recovering the yield loss due to stress at critical periods.

It general the mid season stage is most sensitive to water shortage because the shortage during this period will be reflected significantly on yield. For most of the crops the least sensitive stages are ripening and harvesting except for vegetables like Lettuce, Cabbage etc., which need water upto harvesting.

Under scarce condition, in an irrigation project or in a farm, if mono cropping is followed with staggered sowing or planting, it is better to schedule irrigation to crop which has reached mid season stage since it is the most critical stage.

The sensitive stages vary from crop to crop as given below.

Sensitive stage of different crops cereals and millets

Crop	-	Critical stages / Sensitive stages
Rice	-	Panicle initiation critical staps. heading and flowering
Sorghum	-	Flowering and grain formation
Maize	-	Just prior to tasseling and grain filling
Cumbu	-	Heading and flowering
Ragi	-	Primordial initiation and flowering
Wheat	-	Crown root initiation, tillering and booting
Oil seeds		
Groundnut	-	Flowering peg initiation and penetration and pod development
Sesame	-	Blooming to maturity
Sunflower	-	Two weeks before and after flowering
Soybean	-	Blooming and seed formation

Safflower	-	From rosette to flowering
Castor	-	Full growing period
Cash crop		
Cotton	-	Flowering and Boll formation
Sugarcane	-	Maximum vegetative stage
Tobacco	-	Immediately after transplanting
Vegetables		
Onion	-	Bulb formation to maturity
Tomato	-	Flowering and fruit setting
Chillies	-	Flowering
Cabbage	-	Head formation to maturity
Legumes		
Alfalfa	-	Immediately after cutting for hay crop and flowering for seed crop
Beans	-	Flowering and pod setting
Peas	-	Flowering and pod formation
Others		
Coconut	-	Nursery stage root enlargement
Potato	-	Tuber initiation and maturity
Banana	-	Throughout the growth
Citrus	-	Flowering, fruit setting and enlargement
Mango	-	Flowering
Coffee	-	Flowering and fruit development

At critical stages, favourable water level should be ensured through timely irrigations