Water Requirements of Crop

Introduction

Water Requirement

All field crops need soil, water, air and light (sunshine) to grow. The soil gives stability to the plants; it also stores the water and nutrients which the plants can take up through their roots. The sunlight provides the energy which is necessary for plant growth. The air allows the plants to "breath".

Without water crops cannot grow. Too much water is not good for many crops either. Apart from paddy rice, there are only very few crops which like to grow "with their feet in the water". The most well-known source of water for plant growth is rain water.

There are two important questions which come to mind: What to do if there is too much rain water? What to do if there is too little rain water?

If there is too much rain, the soil will be full of water and there will not be enough air. Excess water must be removed. The removal of excess water - either from the ground surface or from the root zone - is called **drainage**.

If there is too little rain, water must be supplied from other sources; **irrigation** is needed. The amount of irrigation water which is needed depends not only on the amount of water already available from rainfall, but also on the total amount of water needed by the various crops.

Climate Zones

With respect to the need for irrigation water, a distinction can be made among three climatic situations:

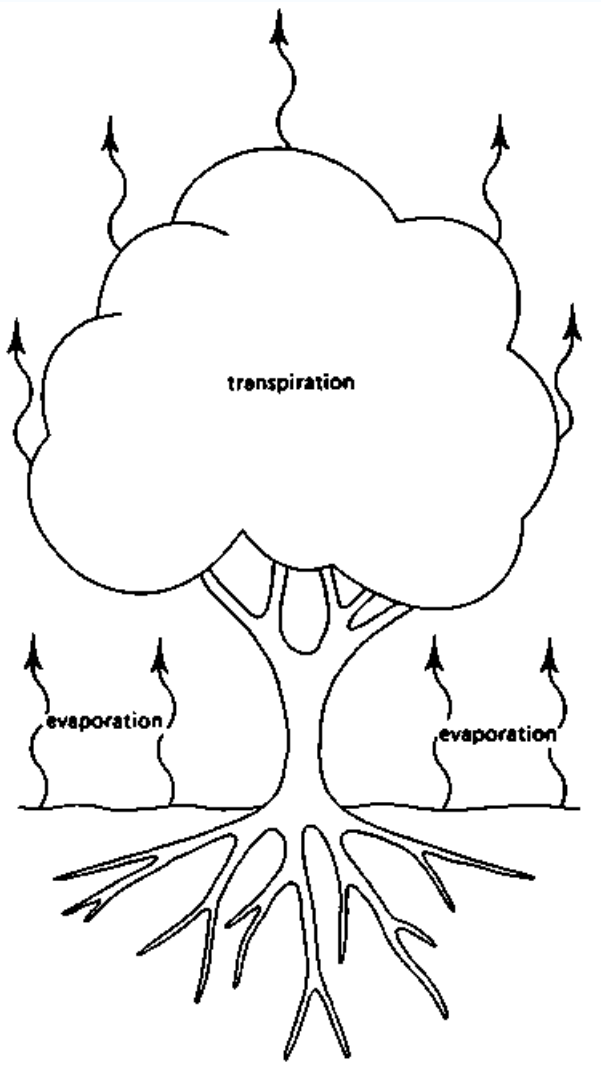
1. **Humid climates**: more than 1200 mm of rain per year. The amount of rainfall is sufficient to cover the water needs of the various crops. Excess water may cause problems for plant growth and thus drainage is required.

2. **Sub-humid and semi-arid climates**: between 400 and 1200 mm of rain per year. The amount of rainfall is important but often not sufficient to cover the water needs of the crops. Crop production in the dry season is only possible with irrigation, while crop production in the rainy season may be possible but unreliable: yields will be less than optimal.

3. **Semi-arid, arid and desert climates**: less than 400 mm of rain per year. Reliable crop production based on rainfall is not possible; irrigation is thus essential.

Evapotranspiration

Crops need water for transpiration and evaporation.



Transpiration

The plant roots extract water from the soil to live and grow. The main part of this water does not remain in the plant, but escapes to the atmosphere as vapour through the plant's leaves and stem. This process is called **transpiration**. Transpiration happens mainly during the day time.

Evaporation

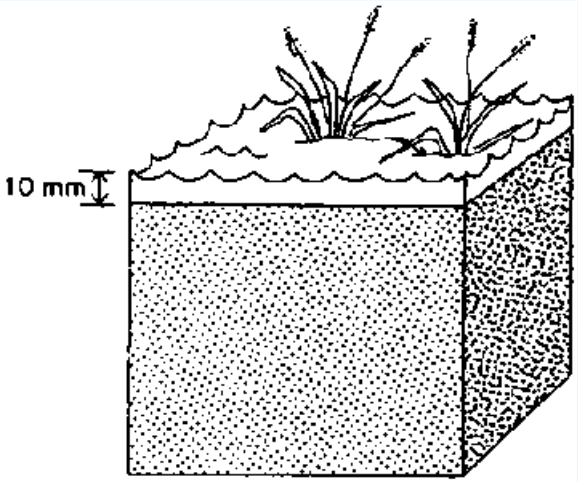
Water from an open water surface escapes as vapour to the atmosphere during the day. The same happens to water on the soil surface and to water on the leaves and stem of a plant. This process is called **evaporation.**

The water need of a crop thus consists of *transpiration plus evaporation*. Therefore, the crop water need is also called **evapotranspiration**.

Evapotranspiration

The water need of a crop is usually expressed in mm/day, mm/month or mm/season.

Suppose the water need of a certain crop in a very hot, dry climate is 10 mm/day. This means that each day the crop needs a water layer of 10 mm over the whole area on which the crop is grown. It does not mean that this 10 mm has to indeed be supplied by rain or irrigation every day.



It is, of course, still possible to supply, for example, 50 mm of irrigation water every 5 days. The irrigation water will then be stored in the root zone and gradually be used by the plants: every day 10 mm.

Factors Affecting

The crop water need mainly depends on:

- **Climate**: for example, in a sunny and hot climate crops need more water per day than in a cloudy and cool climate.
- **Crop type**: crops like rice or sugarcane need more water than crops like beans and wheat.
- **Growth stage**: grown crops need more water than crops that have just been planted.

Climate

A certain crop grown in a sunny and hot climate needs per day more water than the same crop grown in a cloudy and cooler climate.

There are, however - apart from **sunshine** and **temperature** - other climatic factors which influence the crop water need. These factors are the **humidity** and the **windspeed**. When it is dry, the crop water needs are higher than when it is humid. In windy climates the crops will use more water than in calm climates.

Effect of major climatic factors on crop water needs

Climatic Factor	Cropwater Need	
	High	Low
Sunshine	Sunny	Cloudy
Temperature	Hot	Cool
Humidity	Low (dry)	High (humid)
Wind speed	Windy	Little wind

Reference Crop

The highest crop water needs are thus found in areas which are hot, dry, windy and sunny. The lowest values are found when it is cool, humid and cloudy with little or no wind.

From the previous table, it is clear that one crop grown in different climatic zones will have different water needs. For example, a certain maize variety grown in a cool climate will need less water per day than the same maize variety grown in a hotter climate.

It is therefore useful to take a certain standard crop or reference crop and determine how much water this crop needs per day in the various climatic regions. As a standard crop or reference crop grass has been chosen.

Climate	Mean daily temperature ($^{\circ}$C)		
	Low	Medium	High
	< 15	(15 - 25)	(> 25)
Desert/arid	4-6	7-8	9-10
Semi arid	4-5	6-7	8-9
Sub-humid	3-4	5-6	7-8
Humid	1-2	3-4	5-6

For example, the standard grass crop grown in a semi-arid climate with a mean temperature of 20℃ needs approximately 6.5 mm of water per day. The same grass crop grown in a sub-humid climate with a mean temperature of 30℃ needs some 7.5 mm of water per day.

This daily water need of the standard grass crop is also called "reference crop evapotranspiration" or ETo.

Other Crops

Water requirement of other crops are determined with reference to the standard grass crop. The requirement is typically dependent on the particular crop type. This crop type influences the crop water need in two important ways:

Daily requirement: The crop type has an influence on the daily water needs of a fully grown crop; i.e. the peak daily water needs: a fully developed maize crop will need more water per day than a fully developed crop of onions.

Other Crops

Seasonal requirement: The crop type has an influence on the duration of the total growing season of the crop. There are short duration crops, e.g. peas, with a duration of the total growing season of 90-100 days and longer duration crops, e.g. melons, with a duration of the total growing season of 120-160 days. And then there are, of course, the perennial crops that are in the field for many years, such as fruit trees.

While, for example, the daily water need of melons may be less than the daily water need of peas, the seasonal water need of melons will be higher than that of beans because the duration of the total growing season of melons is much longer.

Estimation for Other Crops

In this section it will be explained how the daily water needs of other crops can be estimated using as a basis the daily water need of the standard grass.

It will be easy to understand that a fully grown maize crop - with its large leaf area - will use more water per day than, for example, a fully grown crop of radishes or onions; that is when the two crops are grown in the same area.

Estimation for Other Crops

When determining the influence of the crop type on the daily crop water needs, reference is always made to a fully grown crop; the plants have reached their maximum height; they optimally cover the ground; they possibly have started flowering or started grain setting. When the crops are fully grown their water need is the highest. It is the so-called "peak period" of their water needs.

For the various field crops it is possible to determine how much water they need compared to the standard grass. A number of crops need less water than grass, a number of crops need more water than grass and a number of crops need more or less the same amount of water as grass.

Estimation for Other Crops

The following table indicates five groups of crops. Crops in column 1 need 30% less water than grass in their peak period. Crops in column 2 need 10% less water than grass. Crops in column 3 need the same amount of water as grass. Crops in columns 4 and 5 need respectively 10 and 20% more water than grass in their peak period.

Column 1	**Column 2**	**Column 3**	**Column 4**	**Column 5**
-30%	**-10%**	**same as standard grass**	**10%**	**20%**
citrus	cucumber	carrots	barley	paddy rice
olives	radishes	cabbage, cauliflower	beans	sugarcane
grapes	squash	lettuce	maize	banana
		melons	lentil	Fruits and nuts
		onions	small grains	
		peanuts	cotton	
		peppers	tomato	
		spinach	wheat	
		tea	sunflower	
		grass	millet	
		cacao	oats	
		coffee	peas	
		apples	potatoes	

Example

Estimate the water needs of citrus, bananas, onions, cucumber, clean cultivated apple trees and millet for an area where the water need of standard grass is 6.0 mm/day.

Solution

Citrus: -30% (compared to grass); thus the water need of citrus is 6.0 - 30% = 6.0 -1.8 = 4.2 mm/day

Bananas: +20%; thus the water need of bananas is 6.0 + 20% = 6.0 + 1.2 = 7.2 mm/day

Onions: same as grass; thus the water need of onions is 6.0 mm/day

Cucumber: -10%; thus the water need of onions is 6.0 - 10% =6.0-0.6 =5.4 mm/day

Apples (clean): same as grass; thus the water need of clean cultivated apples is 6.0 mm/day

Millet: +10%; thus the water need of millet is 6.0 + 10% =6.0+0.6 = 6.6 mm/day

Growing Period

Duration of the total growing season has an enormous influence on the seasonal crop water need. There are, for example, many rice varieties, some with a short growing cycle (e.g. 90 days) and others with a long growing cycle (e.g. 150 days). This has a strong influence on the seasonal rice water needs: a rice crop which is in the field for 150 days will need in total much more water than a rice crop which is only in the field for 90 days. Of course, for the two rice crops the daily peak water need may still be the same, but the 150 day crop will need this daily amount for a longer period.

The time of the year during which crops are grown is also very important. A certain crop variety grown during the cooler months will need substantially less water than the same crop variety grown during the hotter months.

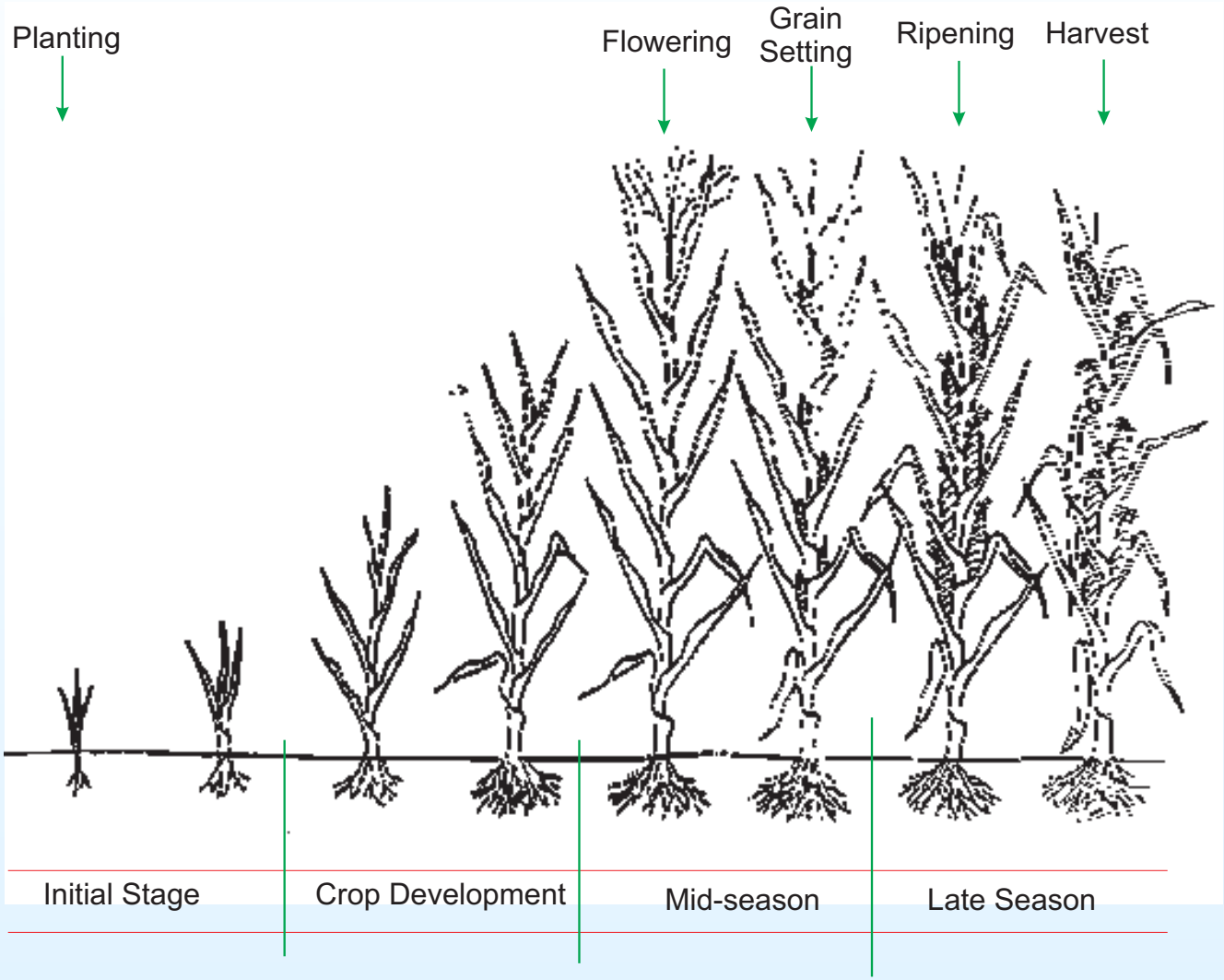
Growing Period

Indicative values of the total growing period

Crop	Total growing period (days)	Crop	Total growing period (days)
Alfalfa	100-365	Millet	105-140
Banana	300-365	Onion green	70-95
Barley/Oats/Wheat	120-150	Onion dry	150-210
Bean green	75-90	Groundnut	130-140
Bean dry	95-110	Pea	90-100
Cabbage	120-140	Pepper	120-210
Carrot	100-150	Potato	105-145
Citrus	240-365	Radish	35-45
Cotton	180-195	Rice	90-150
Cucumber	105-130	Sorghum	120-130
Eggplant	130-140	Soybean	135-150
Flax	150-220	Spinach	60-100
Grain/small	150-165.	Squash	95-120
Lentil	150-170	Sugarbeet	160-230
Lettuce	75-140	Sugarcane	270-365
Maize sweet	80-110	Sunflower	125-130
Maize grain	125-180	Tobacco	130-160
Melon	120-160	Tomato	135-180

Growth Periods

Growth Stages of a Crop



Crop Seasons

There are two main crop seasons in India

- Rabi season
- Kharif Season

Rabi crops are also known as *winter crops* and Kharif crops are known as *monsoon crops*. Normally Rabi crops are sown in the month of October and harvested by the end of March. Whereas, Kharif crops are sown in the month of April and are harvested by the end of September. However, the sowing and harvesting time of the crops grown during these seasons may vary from place to place.

Crop Seasons

Overlap

There are certain crops which have a longer period between their sowing and harvesting time, which extends from one crop season to the other. For example, sugarcane is sown sometimes during February to March and harvested during November to March next year. Thus sugarcane takes almost a full year for maturity covering both the crop seasons and thus known as a *perennial crop*.

Crop Seasons

Hot-weather Crop

Sometimes in between Rabi and Kharif, intermediate crops are grown, which are known as How-weather crops. Hot-weather crops are sown in February and harvested during May or early June. Hot-weather crops and Kharif crops are together called as *Summer crops*.

Crop Period

Crop Period

Crop period is defined as the total time between the sowing of the crop and its harvesting. It actually represents the total time during which the crp remains in the field.

Base Period

Base period is defined as the total time between the first watering done for the preparation of the land for sowing of the crop and the last watering done before its harvesting. Thus base period is little shorter than base period of any crop.

Both crop period and base period are expressed in days.

Duty

Definition

Duty of water is the relation between the are of the land irrigated and the quantity of water required to be supplied for growing a crop. It is usually defines as the area of land in hectares which can be irrigated for growing any crop if one cumec (1 m^3/s) of water is supplied continuously to the land for the entire base period of the crop. It is usually expressed in D hectares/cumec.

For example, if 1500 hectares of land can be irrigated for growing any crop by *one cumec* of water supplied continuously for the entire base period of the crop then the duty of water for this crop is 1500 hectares/cumec.

Duty (contd..)

Factors Affecting Duty

Duty of water mainly depends on the following factors

- Type of crop
- Climatic condition of the area
- System of irrigation
- Method of irrigation
- Quality of irrigation water
- Method of cultivation
- Time of irrigation and frequency of cultivation
- Type of soil and sub-soil of the irrigated field
- Type of soil and sub-soil of the area through which the canal passes
- Canal condition
- Method of assessment of irrigation water rate
- Skill of the cultivator
- Topography of land
- Base period of crop

Delta

Definition

Delta is defined as the total depth of water over the irrigated land required by a crop grown on it during the entire base period. It is denoted by the symbol Δ. The Δ for any crop may be determined by dividing the total quantity of water in ha-m required by the crop for its growth, by the area of the land in ha over which the crop is growing.

Relation between D and Δ

Let

B = Base period of the crop, in days

D = Duty of water on the field, in ha/cumec

Δ = Delta or total depth of water supplied to a crop growing on the field during the entire base period, in m

Volume of water supplied to the field @ 1 m^3/s for B days =

$$1 \times B \times 24 \times 60 \times 60 = 8.64 \times 10^4 \text{ m}^3$$

This volume will stand over D ha area with a depth Δ. So

$$D \times \Delta \times 10^4 = 8.64 \times 10^4$$

or

$$\boxed{D = \frac{8.64 \times B}{\Delta}}$$