



CHAPTER 2: CROP WATER NEEDS

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Crops need water for transpiration and evaporation (see Volume 1, Section 4.2).

The plant roots suck or 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.

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** (Fig. 4).

The water need of a crop thus consists of transpiration plus evaporation. Therefore, the crop water need is also called "**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 (Fig. 5). 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.

Fig. 4 Evapotranspiration

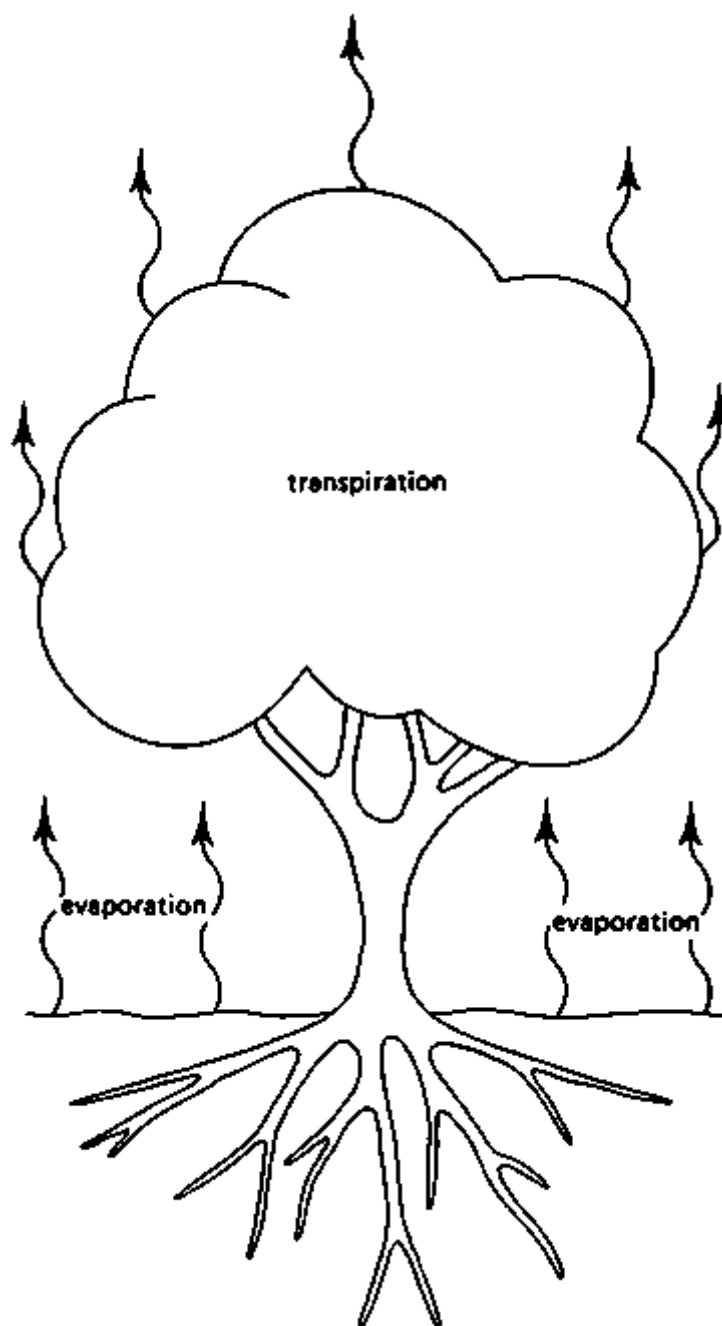
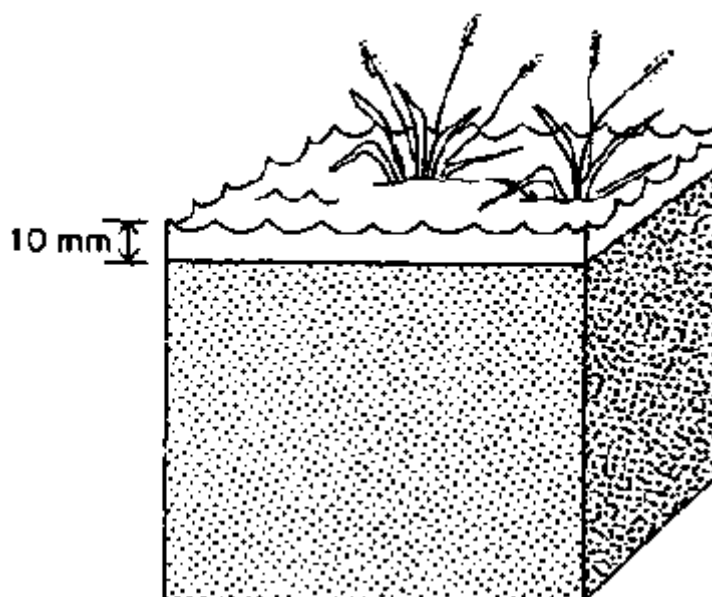


Fig. 5 A crop water need of 10 mm/day



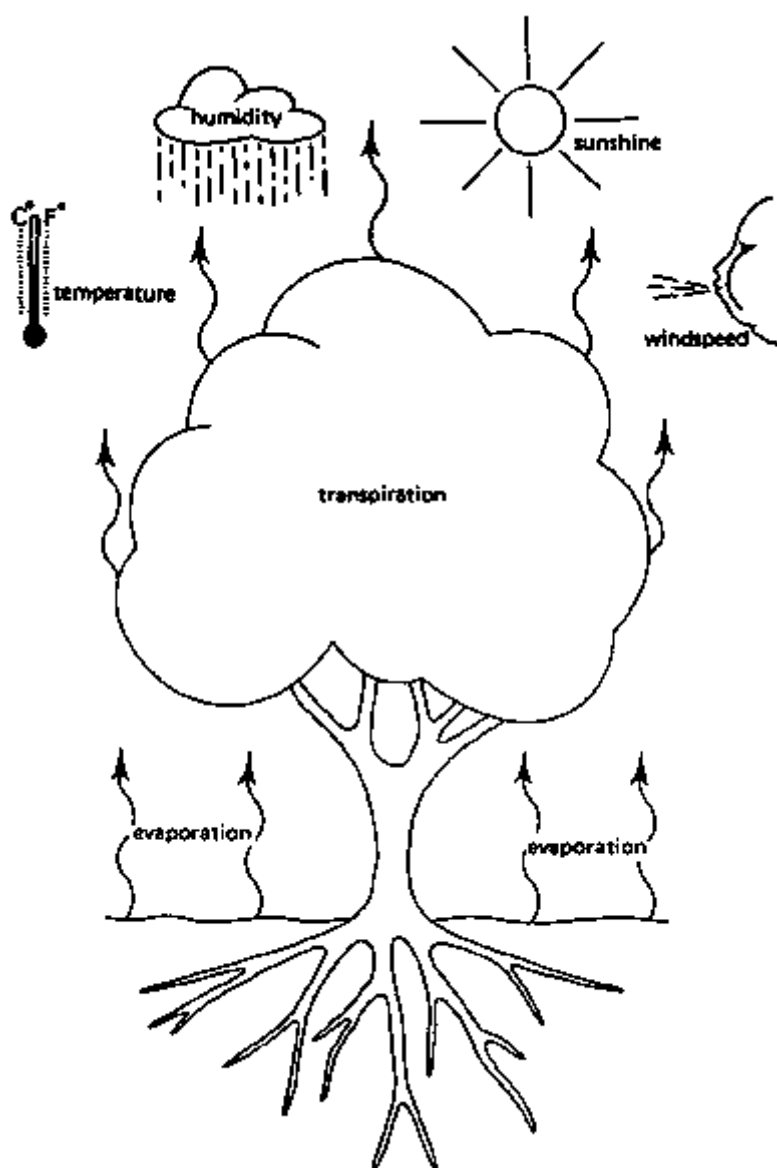
The crop water need mainly depends on:

- **the climate:** for example, in a sunny and hot climate crops need more water per day than in a cloudy and cool climate (see Section 2.1)
- **the crop type:** crops like rice or sugarcane need more water than crops like beans and wheat (see Section 2.2)
- **the growth stage:** grown crops need more water than crops that have just been planted (see Section 2.3).

2.1 THE INFLUENCE OF THE CLIMATE ON CROP WATER NEEDS

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 (see Fig. 6). 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.

Fig. 6 Major climatic factors influencing crop water needs



The effect of these four climatic factors on the water need of the crop is shown in Table 1.

Table 1 EFFECT OF MAJOR CLIMATIC FACTORS ON CROP WATER NEEDS

Climatic Factor	Crop water need	
	High	Low

Sunshine	sunny (no clouds)	cloudy (no sun)
Temperature	hot	cool
Humidity	low (dry)	high (humid)
Windspeed	windy	little wind

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 above 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.

Table 2 indicates the average daily water needs of this reference grass crop. The daily water needs of the grass depend on the climatic zone (rainfall regime) and daily temperatures.

Table 2 AVERAGE DAILY WATER NEED OF STANDARD GRASS DURING IRRIGATION SEASON

Climatic zone	Mean daily temperature		
	low	medium	high
	(less than 15°C)	(15-25°C)	(more than 25°C)
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°C 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°C needs some 7.5 mm of water per day.

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

What will be discussed in the next section is "how do the water needs of the crops grown on, for an example, an irrigation scheme relate to the water need of the standard grass".

2.2 INFLUENCE OF THE CROP TYPE ON THE CROP WATER NEEDS

[2.2.1 Influence of Crop Type on the Daily Crop Water Needs](#)

[2.2.2 Influence of Crop Type on the Seasonal Crop Water Needs](#)

The influence of the crop type on the crop water need is important in two ways:

1. 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.
2. 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.

The influences of the crop type on both the daily and seasonal crop water needs are discussed in the sections below.

2.2.1 Influence of Crop Type on the Daily Crop Water Needs

In the previous section it has been indicated how the daily water need of standard grass can be estimated. 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.

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 (Fig. 7). 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.

Fig. 7 How much water does maize need, compared to the standard grass?

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

Table 3 CROP WATER NEEDS IN PEAK PERIOD OF VARIOUS FIELD CROPS AS COMPARED TO STANDARD GRASS

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	crucifers (cabbage, cauliflower, broccoli, etc.)	beans	sugarcane
grapes	squash	lettuce	maize	banana
		melons	flax	nuts & fruit trees with cover crop
		onions	small grains	
		peanuts	cotton	
		peppers	tomato	
		spinach	eggplant	
		tea	lentils	
		grass	millet	
		cacao	oats	
		coffee	peas	

		clean cultivated nuts & fruit trees e.g. apples	potatoes	
			safflower	
			sorghum	
			soybeans	
			sugarbeet	
			sunflower	
			tobacco	
			wheat	

EXAMPLE

Suppose in a certain area the standard grass crop needs 5.5 mm of water per day.

Then, in that same area, maize will need 10% more water. Ten percent of 5.5 mm = $10/100 \times 5.5 = 0.55$ mm. Thus maize would need $5.5 + 0.55 = 6.05$ or rounded 6.1 mm of water per day.

QUESTION

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.

ANSWER

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
	If the apples have a cover crop in between the trees, the water need would be 20% higher than grass and thus: $6.0 + 20\% = 6.0 + 1.2 = 7.2$ mm/day.
Millet:	+10%; thus the water need of millet is $6.0 + 10\% = 6.0 + 0.6 = 6.6$ mm/day

2.2.2 Influence of Crop Type on the Seasonal Crop Water Needs

The crop type not only has an influence on the **daily water need** of a fully grown crop, i.e. the daily peak water need, but the crop type also has an influence on the duration of the total growing season of the crop, and thus on the **seasonal water need**.

Data on the duration of the total growing season of the various crops grown in an area can best be obtained locally. These data may be obtained from, for example, the seed supplier, the Extension Service, the Irrigation Department or Ministry of Agriculture.

The 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.

Table 4 gives some Indicative values or approximate values for the duration of the total growing season for the various field crops. It should, however, be noted that these values are only rough approximations and it is much better to obtain the values locally.

Table 4 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	Peanut/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

As can be seen from Table 4 there is a large variation of values not only between crops, but also within one crop type. In general it can be assumed that the growing period for a certain crop is longer when the climate is cool and shorter when the climate is warm.

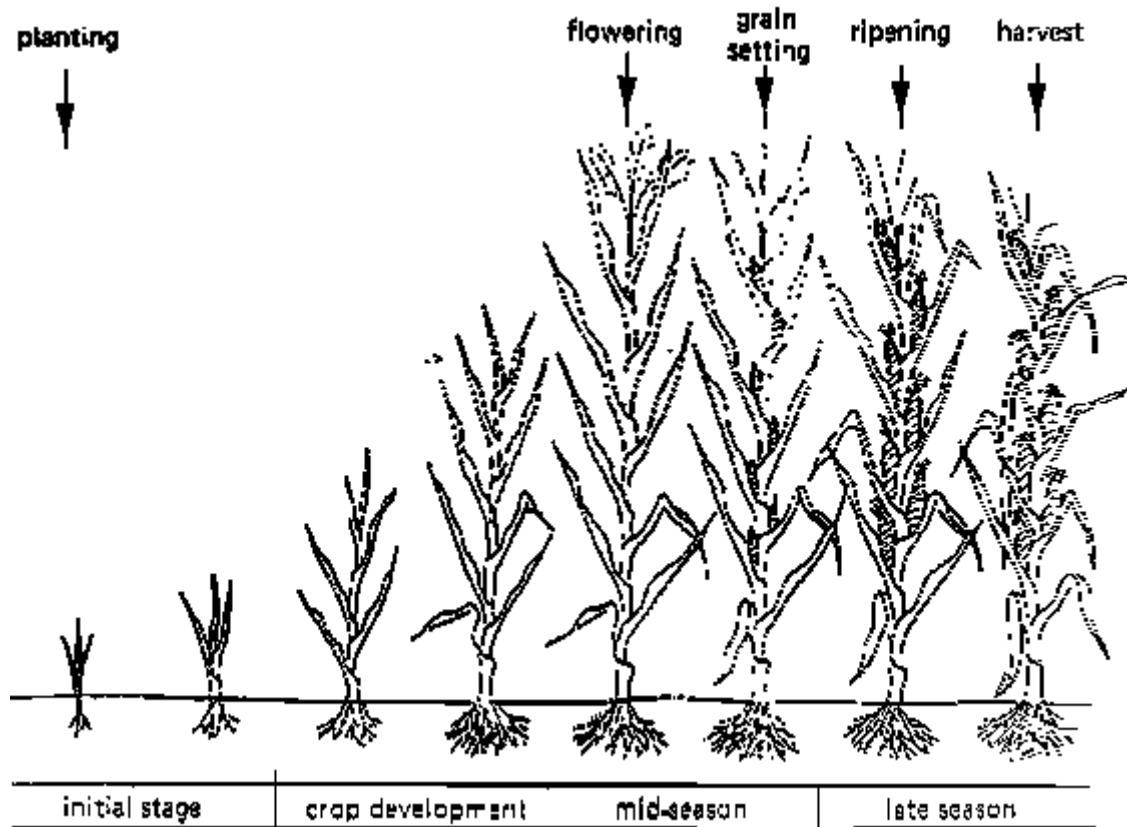
2.3 INFLUENCE OF THE GROWTH STAGE OF THE CROP ON CROP WATER NEEDS

A fully grown maize crop will need more water than a maize crop which has just been planted.

As has been discussed before, the crop water need or crop evapotranspiration consists of transpiration by the plant and evaporation from the soil and plant surface. When the plants are very small the evaporation will be more important than the transpiration. When the plants are fully grown the transpiration is more important than the evaporation.

Figure 8 shows in a schematic way the various development or growth stages of a crop.

Fig. 8 Growth stages of a crop



At planting and during the initial stage, the evaporation is more important than the transpiration and the evapotranspiration or crop water need during the initial stage is estimated at 50 percent of the crop water need during the mid - season stage, when the crop is fully developed.

During the so-called crop development stage the crop water need gradually increases from 50 percent of the maximum crop water need to the maximum crop water need. The maximum crop water need is reached at the end of the crop development stage which is the beginning of the mid-season stage.

With respect to the late season stage, which is the period during which the crop ripens and is harvested, a distinction can be made between two groups of crops:

Fresh harvested crops: such as lettuce, cabbage, etc. With these crops the crop water need remains the same during the late season stage as it was during the mid-season stage. The crops are harvested fresh and thus need water up to the last moment.

Dry harvested crops: such as cotton, maize (for grain production), sunflower, etc. During the late season stage these crops are allowed to dry out and sometimes even die. Thus their water needs during the late season stage are minimal. If the crop is indeed allowed to die, the water needs are only some 25 percent of the crop water need during the mid-season or peak period. Of course, no irrigation is given to these crops during the late season stage.

2.4 DETERMINATION OF CROP WATER NEEDS

In the previous sections it has been explained on which factors - the climate, the crop type and the growth stage - the crop water need depends.

To calculate the water needs for the various months during which the crop is grown is fairly complicated and explained in Part II of this manual.

As stated before, it is often possible to obtain data on crop water needs locally and it is thus not necessary to calculate them. However, to give the reader some idea on values of seasonal water needs for the most important field crops. Table 5 can be used as a guide.

Table 5 APPROXIMATE VALUES OF SEASONAL CROP WATER NEEDS

Crop	Crop water need (mm/total growing period)
Alfalfa	800-1600
Banana	1200-2200
Barley/Oats/Wheat	450-650
Bean	300-500
Cabbage	350-500
Citrus	900-1200
Cotton	700-1300
Maize	500-800
Melon	400-600
Onion	350-550
Peanut	500-700
Pea	350-500
Pepper	600-900
Potato	500-700
Rice (paddy)	450-700
Sorghum/Millet	450-650
Soybean	450-700
Sugarbeet	550-750
Sugarcane	1500-2500
Sunflower	600-1000
Tomato	400-800

