Sugarcane

This section presents information on water relations and water management of sugarcane and provides links to other sources of information.

Crop Description and Climate
The present area of sugarcane (*Saccarum officinarum*) is about 13 million ha with a total commercial world production of about 1254.8 million ton/year cane or 55 million ton/year sucrose. (FAOSTAT, 2001).

Sugarcane originated in Asia, probably in New Guinea. Most of the rainfed and irrigated commercial sugarcane is grown between 35°N and S of the equator. The crop flourishes under a long, warm growing season with a high incidence of radiation and adequate moisture, followed by a dry, sunny and fairly cool but frost-free ripening and harvesting period.

Optimum temperature for sprouting (germination) of stem cuttings is 32 to 38°C. Optimum growth is achieved with mean daily temperatures between 22 and 30°C. Minimum temperature for active growth is approximately 20°C. For ripening, however, relatively lower temperatures in the range of 20 to 10°C are desirable, since this has a noticeable influence on the reduction of vegetative growth rate and the enrichment of sucrose in the cane.

A long growing season is essential for high yields. The normal length of the total growing period varies between 9 months with harvest before winter frost to 24 months in Hawaii, but it is generally 15 to 16 months. Plant (first) crop is normally followed by 2 to 4 ratoon crops, and in certain cases up to a maximum of 8 crops are taken, each taking about 1 year to mature. Growth of the stool is slow at first, gradually increasing until the maximum growth rate is reached after which growth slows down as the cane begins to ripen and mature. The flowering of sugarcane is controlled by daylength, but it is also influenced by water and nitrogen supply. Flowering has a progressive deleterious effect on sucrose content.Normally, therefore, flowering is prevented or non-flowering varieties are used.

Sugarcane does not require a special type of soil. Best soils are those that are more than 1 m deep but deep rooting to a depth of up to 5 m is possible. The soil should preferably be well-aerated (after heavy rain the pore space filled with air > 10 to 12 percent) and have a total available water content of 15 percent or more. When there is a groundwater table it should be more than 1.5 to 2.0 m below the surface. The optimum soil pH is about 6.5 but sugarcane will grow in soils with pH in the range of 5 to 8.5

Sugarcane has high nitrogen and potassium needs and relatively low phosphate requirements, or 100 to 200 kg/ha N, 20 to 90 kg/ha P and 125 to 160 kg/ha K for a yield of 100 ton/ha cane, but application rates are sometimes higher. At maturity, the nitrogen content of the soil must be as low as possible for a good sugar recovery, particularly where the ripening period is moist and warm.

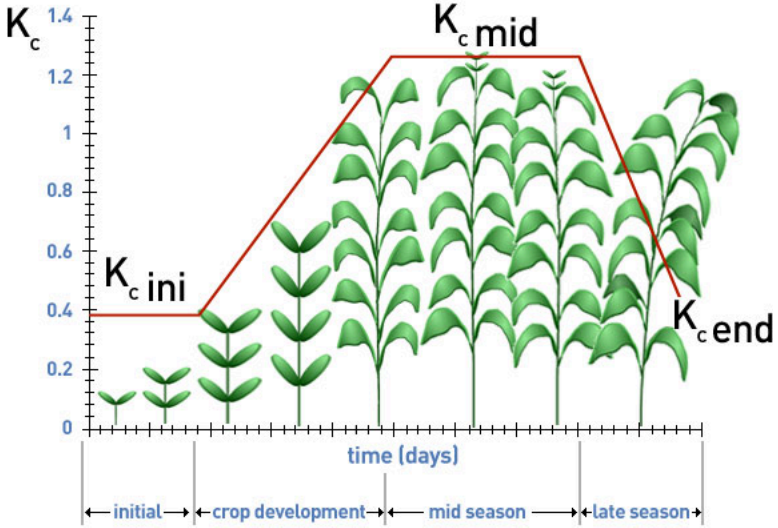
Row spacing varies usually between 1.1 and 1.4 m; number of sets per ha depends on the number of buds per set and may vary between 21000 and 35000.

Sugarcane is moderately sensitive to salinity and decrease in crop yield due to increasing salinity is: 0% at ECe 1.7 mmhos/cm, 10% at 3.3, 25% at 6.0, 50% at 10.4 and 100% at ECe 18.6 mmhos / cm.

The graph below depicts the crop stages of sugarcane, and the table summarises the main crop coefficients used for water management.

- Onion
- Pepper
- Tomato
- Watermelon

- CropWat
- CLIMWAT
- Diagnostic Tools for Investment
- FAO Nile
- ETo Calculator
- GAEZ
- GeoNetwork
- GLADIS
- HWSD
- PRISM
- Rapid Appraisal Procedure (RAP)
- SoiLEX
- SoilSTAT
- WaPOR
- WaterLex



	Stages of Development					Plant date	Region
Crop characteristic	**Initial**	**Crop Development**	**Mid-season**	**Late**	**Total**		
Stage length, days							
Sugarcane-virgin	35	60	190	120	405		Low Latitudes
	50	70	220	140	480		Tropics
	75	105	330	210	720		Hawaii, USA
Sugarcane-ratoon	25	70	135	50	280		Low Latitudes
	30	50	180	60	320		Tropics
	35	105	210	70	420		Hawaii, USA
Depletion Coefficient, p:	-	-	-	-	0.65		
Root Depth, m	-	-	-	-	1.5		
Crop Coefficient,Kc	0.4	>>	1.25	0.75	-		
Yield Response Factor, Ky	0.75	-	0.5	0.1	1.2		

Water Requirements

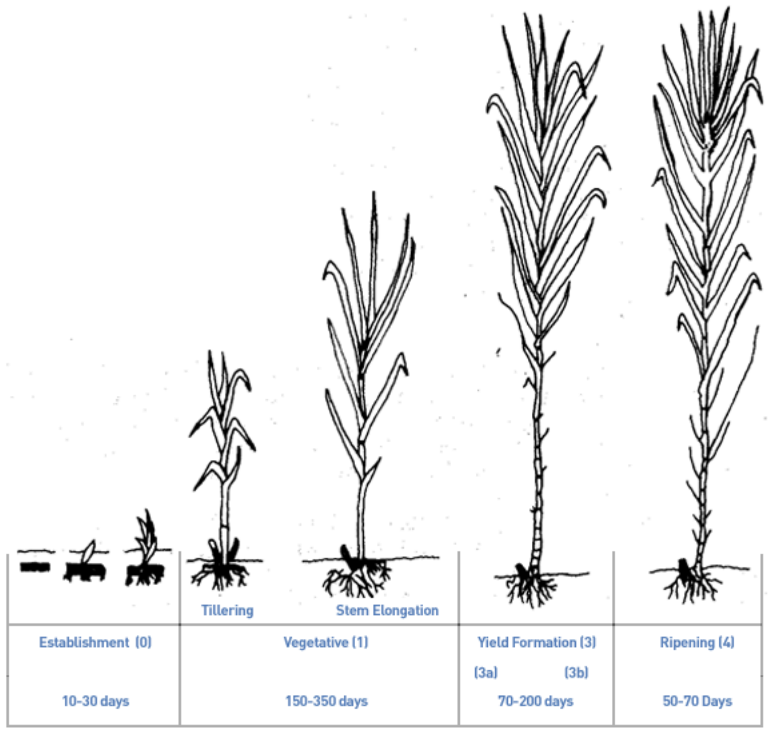
Adequate available moisture throughout the growing period is important for obtaining maximum yields because vegetative growth including cane growth is directly proportional to the water transpired. Depending on climate, water requirements (ETm) of sugarcane are 1500 to 2500 mm evenly distributed over the growing season.

The crop coefficient (kc) values, relating ETm to reference evapotranspiration (ETo) for the different growth stages are presented in the following table.

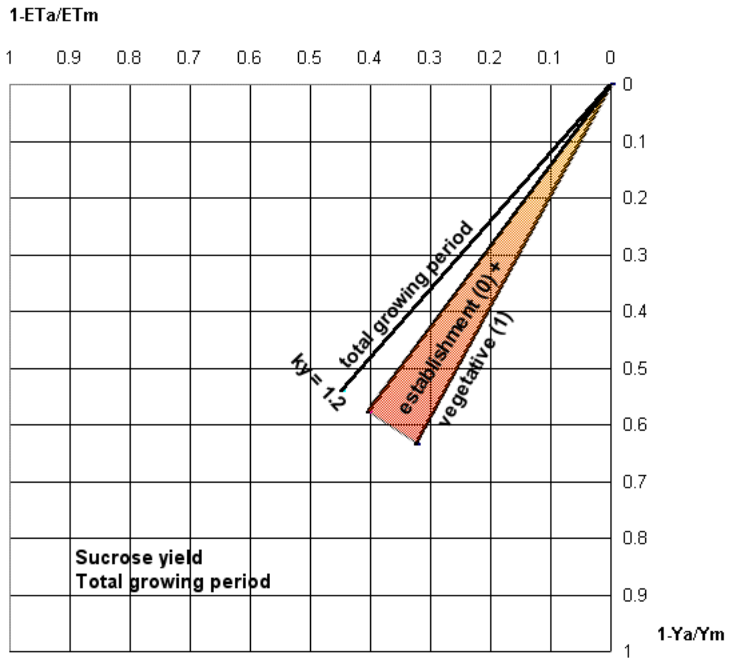
Development stages	days	Kc coefficients*
planting to 0.25 full canopy	30-60	0.45-0.6
0.25 to 0.5 full canopy	30-40	0.75-0.85
0.50 to 0.75 full canopy	15-25	0.90-1.00
0.75 to full canopy	45-55	1.00-1.20
peak use	180-330	1.05-1.30
early senescence	30-150	0.80-1.05
ripening	30-60	0.60-0.75

* kc values depend on minimum relative humidity and wind velocity (see Irrigation and Drainage Paper No. 24)

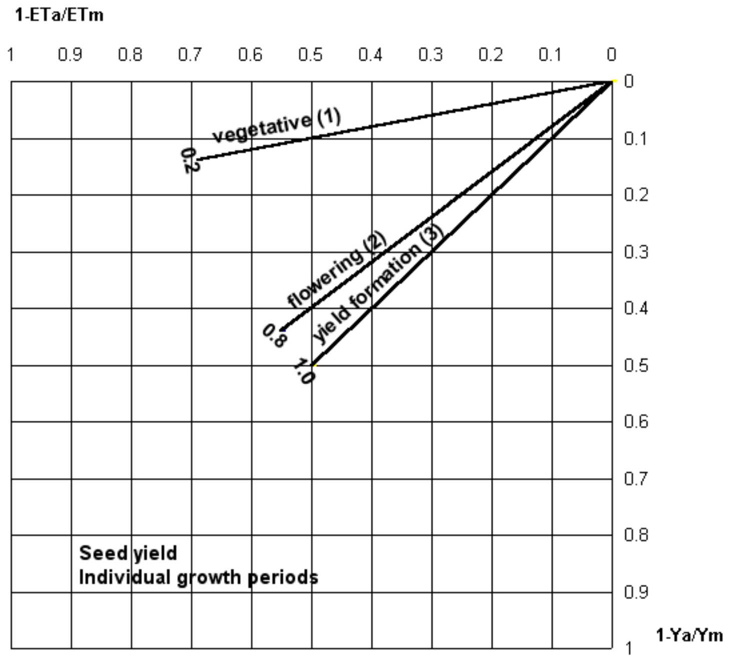
Water Supply And Crop Yield
Following figure shows the growth periods of sugarcane (after Kuyper, 1952)



The relationships between relative yield decrease (1 - Ya/Ym) and relative evapotranspiration deficit for the total growing period of root yield are shown in the figure below.



This figure shows the relationships between relative yield decrease (1 - Ya/Ym) and relative evapotranspiration deficit for the individual growth periods.



Frequency and depth o£ irrigation should vary with growth periods of the cane. During the establishment period (0), including emergence and establishment of young seedlings, light, frequent irrigation applications are preferred. During the early vegetative period (1) the tillering is in direct proportion to the frequency of irrigation. An early flush of tillers is ideal because this furnishes shoots of approximately the same age. During stem elongation (1b) and early yield formation (3a), irrigation interval can be extended but depth of water should be increased. There is a close relationship between stalk elongation during these periods and water use, and adequate water supply is important during this period of active growth when the longest internodes are formed. With adequate supply this period is reached early and also total cane height is greater. The response of sugarcane to irrigation is greater during the vegetative and early yield formation periods (1 and 3a) than during the later part of the yield formation period (3b), when active leaf area is declining and the crop is less able to respond to sunshine. During the ripening period (4), irrigation intervals are extended or irrigation is stopped when it is necessary to bring the crop to maturity by reducing the rate of vegetative growth, dehydrating the cane and forcing the conversion of total sugars to recoverable sucrose. With the check of vegetative growth, the ratio between dry matter stored as sucrose and that used for new growth also increases. During the yield formation period (3) frequent irrigation has an accelerating effect on flowering, which leads to a reduction of sugar production.

Water deficit during the establishment period (0) and early vegetative period (tillering, 1a) has an adverse effect on yield as compared to water deficit in later growth periods. Water deficit slows down germination and tillering and the number of tillers is smaller. Water deficit during the vegetative period (stem elongation, 1b) and early yield formation (3a) causes a lower rate of stalk elongation. Severe water deficit during the later part of yield formation (3b) forces the crop to ripen. During the ripening period (4), a low soil moisture content is necessary. However, when the plant is too seriously deprived of water, loss in sugar content carp be greater than sugar formation.

When water supply is limited, and apart from other considerations, the acreage can be enlarged using water saved during the yield formation period (3); this will result in a slightly lower yield per hectare but overall production will be higher.

Water Uptake

Rooting depth varies with soil type and irrigation regime; infrequent, heavy irrigations normally result in a more extensive root system. Rooting depth can be up to 5 m but active root zone for water uptake is generally limited to the uppermost layers. When these layers are depleted the uptake from greater depth increases rapidly but normally 100 percent of the water is extracted from the first 1.2 to 2.0 m (D = 1.2-2.0 m). With evapotranspiration during the growing season of 5 to 6 mm /day, the depletion level during the vegetative (1) and yield formation period (3) can be 65 percent of the total available water without having any serious effects on yields (p = 0.65).

Irrigation Scheduling

When irrigation water is not scarce, Table 21 can be used to determine frequency and depth of irrigation required for a high yield. Under minimum crop water stress conditions and taking into account the level of ETm, the depletion level of the total available soil water for the establishment period (0) is about 30 percent. Because of the low depletion level and a poorly formed root system, frequent irrigation is required during this period. This applies also to a ratoon crop because a new root system has to be developed.

During the vegetative (1) and yield formation (3) periods, the depletion level (p), depending on ETm, is about 0.65 and frequency and depth of irrigation is very dependent on the water holding capacity of the soil and the root depth. A lower frequency of irrigation with a higher application in depth may cause the development of a deeper root system provided rooting is not restricted by layers which are difficult to penetrate. During the ripening period (4), a low soil water level is required. Irrigation water is applied only in an extremely dry situation but depth of application is reduced.

Where irrigation water is limited and rainfall is scarce, irrigation scheduling should be based on avoiding water stress during the establishment period (0), followed by the vegetative period (1). However, when irrigation water is scarce during period (1), the reduction in the height of canes can be partly regained in the yield formation period (3)

Irrigation Methods

Furrow irrigation is most commonly used and is particularly effective for early plant crop. In later crop growth periods and during ratoon crops, the water distribution may become increasingly problematic because of deterioration of the furrows. Reduced furrow length is sometimes used to allow better distribution of water over the field in a later stage.

A recent trend is in the direction of sprinkler and drip irrigation. For sprinkler irrigation, increasing use is made of spray guns, hand and automatically moved, replacing the cumbersome boom and labour-intensive hand-moved sprinkler laterals Prevailing winds of more than 4 or 5 m/sec will limit their usefulness. An optimum combination of distance between field roads for harvesting and for moving guns with different spray length must be analysed. Drip irrigation using double wall drip lines has been successfully employed particularly in Hawaii; replacement of burned drip lines after harvest is compensated for by the reduction in the high labour cost.

Yield

Sugar yield depends on cane tonnage, sugar content of the cane and on the cane quality. It is important that the cane is harvested at the most suitable moment when the economic optimum of recoverable sugar per area is reached. Cane tonnage at harvest can vary between 50 and 150 ton/ha or more, which depends particularly or. the length of the total growing period and whether it is a plant or a ratoon crop. Cane yields produced under rainfed conditions can vary greatly. Good yields in the humid tropics of a totally rainfed crop can be in the range of 70 to 100 ton/ha cane, and in the dry tropics and subtropics with irrigation, 110 to 150 ton/ha cane. The water utilization efficiency for harvested yield (Ey) for cane containing about 80 percent moisture is 5 to 8 kg/m^3 and for sucrose containing no moisture 0.6 to 1.0 kg/$m^{3,}$ both with the highest values for good ratoon crops in the subtropics.

Toward maturity, vegetative growth is reduced and sugar content of the cane increases greatly. Sugar content at harvest is usually between 10 and 12 percent of the cane fresh weight, but under experimental conditions 18 percent or more has been observed. Sugar content seems to decrease slightly with increased cane yields. Luxurious growth should be avoided during cane ripening which can be achieved by low temperature, low nitrogen level and restricted water supply. With respect to juice purity, this is positively affected by low minimum temperatures several weeks before harvest.