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**A STUDY ON AVAILABLE SOIL WATER DURING
THE GROWTH OF SUGARCANE (*SACCHARUM
OFFICINARUM* L.) IN GANGETIC PLAINS**

1. Sugarcane is one of the most important commercial crops in India. With over 450 sugar mills and over 11 million tons of refined sugar produced, India is the largest sugar producer in the world. It is grown over an

area of about 4.4 million hectare with annual production of about 300 million tons in the country (SAI, 2002). The average yield of the crop is about 680 q/ha. Uttar Pradesh, Maharashtra, Karnataka, Tamilnadu and Andhra Pradesh are the major sugarcane producing states. The main cash crop in the state of Uttar Pradesh is sugarcane, with nearly 38% of the total production in the country (highest among all the states). The productivity, however, is less than that achieved in other sugarcane growing regions, *e.g.*, 1114 q/ha in Tamilnadu (SAI, 2002). Sugarcane needs specific

TABLE 1

The amount of water consumed (ET) and distribution of rainfall (RF) during the various growth stages in sugarcane

Growth stage	Weeks after sowing (WAS)	Year												Average ET (mm)
		1980 - 81		1981 - 82		1982 - 83		1983 - 84		1984 - 85		1985 - 86		
		ET (mm)	RF (mm)	ET (mm)	RF (mm)	ET (mm)	RF (mm)	ET (mm)	RF (mm)	ET (mm)	RF (mm)	ET (mm)	RF (mm)	
Germination (G)	upto 6	105	0	90	22	87	51	73	0	93	0	69	0	86
Tillering (T)	7 - 17	425	461	374	208	362	170	317	63	386	174	300	0	361
Grand Growth Period (GGP)	18 - 38	838	1601	732	790	720	821	686	965	752	763	600	1332	721
Ripening (R)	39 - 52	199	32	188	68	175	47	155	62	177	35	172	5	178
Total		1567	2094	1384	1088	1344	1089	1231	1090	1408	972	1141	1337	1346
Deficit / Surplus from normal rainfall (mm)		1074		68		69		70		- 48		317		-
Yield (kg / ha)		39091		41818		32830		36364		38929		34156		37198

weather conditions during different growth phases. During the active growth phase, it requires long hours of bright sunshine, high relative humidity with adequate rainfall or irrigation, while during ripening phase it requires warm days, clear skies, cool nights and relatively dry weather (Sundara, 1998).

Water is one of the most essential inputs for successfully raising crops and obtaining maximum yield. Long periods of dry spell and drought like situations often cause the crop to suffer from water stress and when the stress period coincides with the critical growth stage of the crop, the growth, development and yield are adversely affected (Hunsigi and Krishna, 1998). So, the scheduling of irrigation needs to be done in such a way that the crop does not suffer from water stress. It may be achieved by timely irrigating the crop, as soon as available soil water in the root zone reaches allowable depletion limit. (Bhan *et al.* 1990 ; IARI, 1977 ; ICAR, 1997). The optimum allowable depletion limit of available soil water for sugarcane has been found to be 75 percent of the available soil water during germination phase and 50 percent for rest of the growth period. However, irrigation is withheld at least four weeks before harvest (Michael, 1990; Sundara, 1998). In this paper, distribution of rainfall in relation to water needs of the crop during various stages of its growth and available soil water depletion in the root zone in relation to growth and yield of sugarcane have been discussed.

2. The study is based on the sugarcane crop (variety CO-1148) grown at Central Sugarcane Research

Institute, Lucknow (26° 52' N, 80° 56' E). A data set of six years during the crop growing season between 1980 and 1986 has been utilized. The growth duration of the crop was 52 weeks (*i.e.*, eksali). The water loss of the crop, *i.e.*, evapotranspiration (ET) was measured with gravimetric lysimeter (1.3 × 1.3 × 0.9 m) fixed within the crop, whereas data on meteorological parameters refer to the observatory located near the experimental farm. With regard to water need of the crop, the growth period has been divided into four important phenological growth stages (Table 1) *viz.*, Germination (G), Tillering (T), Grand Growth Period (GGP), and Ripening or Maturity (R) (Sundara, 1998). The Available soil water (Aw), in mm, was calculated using the standard formulae (Michael, 1990);

$$Aw = \frac{(FC - PWP)}{100} \times BD \times d \quad (1)$$

Where,

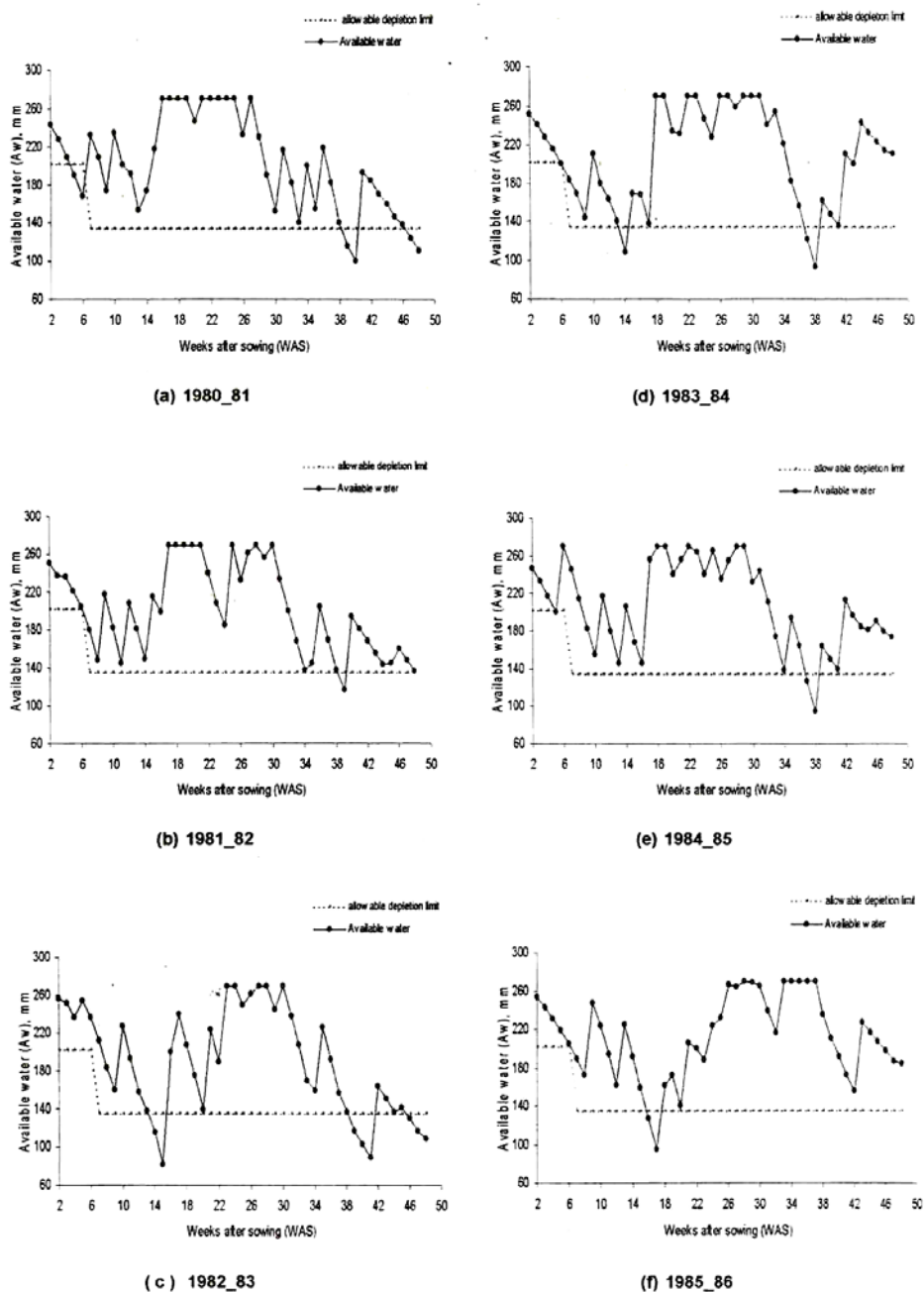
FC = field capacity (percent),

PWP = permanent wilting point (percent),

BD = bulk density of soil (g/cc),

d = root zone depth (cm).

To calculate the actual available soil water in the soil, FC was replaced by actual soil moisture observations and d = 100 cm has been used in the study.



Figs. 1(a-f). Variation of available soil water (Aw) with time (WAS) during 1981-86

3.1. *Rainfall and consumptive use of water (ET)* - Crop yield varied from a maximum of 41818 kg/ha during 1981-82 to a minimum of 32830 kg/ha during 1982-83. The average yield obtained was 37198 kg/ha (Table 1). Rainfall also varied widely from a maximum of 2094 mm during 1980-81 to a minimum of 972 mm during 1984-85.

The average amount of water consumed in different growth stages was found to be maximum (721 mm) during Grand Growth Period, followed by Tillering (361 mm) and Ripening (178 mm) (Table 1). Sugarcane received most of the rainfall (nearly 82 %) during Grand Growth Period, followed by Tillering (nearly 13 %). However, the

quantum of rainfall was not evenly distributed in accordance with water needs of the crop during various stages of its growth. As such, the crop needed four to six irrigations for successfully completing the growth cycle.

3.2. *Available soil water (Aw) in the root zone* - Available soil water (Aw) was calculated, from 2 to 48 weeks after sowing (WAS), using Eqn. (1). Figs. 1(a-f) shows variation of Available soil water (Aw) with time during the growth of Sugarcane. The dotted line in the figures, indicate the allowable depletion limit (202 mm during Germination and 135 mm for rest of the growth stages). As rainfall is a parameter that is not evenly distributed during the various growth stages of the crop, the exact time and frequency of irrigation varies. However, the amount, in each irrigation, was same *i.e.*, about 80 mm. The normal seasonal rainfall at the station during the crop growing period is about 1020 mm.

In the year 1981-82 [Fig. 1(b)], although rainfall was not sufficient to meet water needs of the crop in different growth phases, but due to timely applied irrigations, crop did not suffer from water stress during Germination, Tillering and Grand Growth Period stages. However, it suffered from mild stress during Ripening phase, when Aw reduced up to 116 mm (*i.e.*, 57 % depletion) In this season, the crop could produce maximum yield of 41818 kg/ha. In the remaining years, crop suffered from water stress of varying degrees during various growth stages, when Aw reduced by more than the allowable depletion limit (202 mm during Germination and 135 mm for rest of the growth stages) , thereby adversely affecting the crop yield. It was nearly 7% lower than the maximum yield, when crop suffered from water stress during the Germination, Grand Growth Period and Ripening growth phases [Fig. 1(a) and Fig. 1(e)]. The crop could achieve 13 to 21% lower than the maximum yield during 1983-84 and 1985-86, when crop suffered from water stress during Tillering along with other growth stages [Figs. 1(d&f)]. Crop suffered highest yield loss of 21% during 1982-83, when crop suffered from water stress during Tillering and Ripening growth stages [Fig. 1(c)]. During the Tillering stage, Aw reduced up to 80 mm (*i.e.*, 70 % depletion) and during Ripening phase, Aw reduced up to 88 mm (*i.e.*, 67 % depletion).

4. (i) When available soil water (Aw) in the root zone depleted by more than the optimum allowable depletion limit, the yield was adversely affected. The crop suffered highest yield loss, up to 21% of the maximum

yield, when Aw reduced up to 80 mm (*i.e.*, 70% depletion) during Tillering phase and Aw reduced up to 88 mm (*i.e.*, 67% depletion) during Ripening phase.

(ii) In order to achieve maximum yield, sugarcane needs at least five well-distributed irrigations, along with normal annual rainfall of 1020 mm. The irrigation should be applied as soon as Available soil water reaches optimum allowable depletion limit (*i.e.*, 75% of the Available soil water during Germination phase and 50% for rest of the growth period).

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