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Computation of crop evapotranspiration for scheduling irrigation in sugarcane

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Abstract : Field experiments were carried out to investigate the suitability of empirical formulae of climatological approach for irrigation scheduling, improving the water use efficiency in early maturing sugarcane during main and special seasons (1993-95) at Tamil Nadu Agricultural University, Coimbatore. For scheduling irrigation based on Blaney - Criddle method, ETc was worked out with thirty years mean climatic data. For evaluating various empirical methods including Blaney - Criddle methods, the actual weather parameters that prevailed during the cropping period alone were considered. The estimated ETc was 1223 and 1345 mm for main and special seasons respectively. Blaney - Criddle empirical method of climatological approach promises to be suitable for irrigation scheduling in early maturing sugarcane. For high WUE scheduling irrigation at 100 per cent ETc during germination and early tillering followed by at 75 per cent ETc during subsequent growth phases of cane could be adopted. Climatological methods of predicting ETc and scheduling irrigation for sugarcane could be exploited for various agro climatic zones of Tamil Nadu for efficient water budgeting. *(**Key words** : Sugarcane, Blaney - Criddle Climatological approach. Evapotranspiration, Irrigation scheduling).*

Among several external factors, distinction must be made between those which we can manipulate and those that are independent. It is felt that irrigation water management systems belong to those which cane be modified. Though the yield increase, in recent years, are undoubtedly associated with the yield potential of improved early maturing sugarcane varieties, the most marked fluctuations in yields are mostly related to irrigation management methods. With limited scope fro further exploitation and need for diversion of presently utilised irrigation water to the expanding industries and exploding population, greater urgency for its efficient use is needed the average cane yield in irrigated areas are 67 t ha^{-1} while that in partially irrigated area are 41 t ha^{-1}. Nearly 43 per cent of cane production comes from about 35 per cent of the area which is fully irrigated and the remaining 57 per cent is from the 65 per cent of total water resource of the country is diverted to sugarcane cultivation. Further, it has been estimated that to produce one tonne of cane 250 tonnes of water is needed. While the demand on water for sugarcane is increasing year after year, the availability of water is static or even decreasing in certain areas over years (ICAR, 1987). thus the productivity increase has to come through efficient water use and management.

Knowledge generated thus far is centered around water requirement for higher productivity. Doorenbos and Pruitt (1977) have suggested empirical formula based on climatic parameters to compute crop water requirement. The cane water requirement based on Blaney - Criddle formula for Tamil Nadu has been worked out by Subramanian and Kulandaivelu (1986). These empirical formulae and crop water requirement (ETc) are based on the assumption that water availability is unrestricted. Hence, an on-station field experiment has been conducted to study the usefulness of climatic based empirical formulae for scheduling irrigation and efficient water use in sugarcane.

Materials and Methods

Field experiments were conducted to investigate the suitability of empirical formulae for scheduling irrigation and to evaluate the fitness of methods based on crop evapotranspiration (ETc) for scheduling irrigation. Experiments were conducted in randomized blocks design with four replications during main and special seasons of 1993-95 at Tamil Nadu Agricultural university, Coimbatore.

Treatments on irrigation regimes were designed by taking into consideration the limited water resource situations. Blaney - Criddle methods as described by Doorenbos and Pruitt (1977) was adopted for computed ETo with thirty years mean climatic data ETc was calculated using Kc factor for various growth phases of cane. Kc values adopted during sucessive growth phase are :

Duration (days)	Growth phase	Kc values used
0 to 30	Germination	0.40
30 to 60	Early tillering	0.75
60 to 90	Late tillering	0.95
90 to 150	Formative	1.10
150 to 240	Grand growth	1.25
240 to 270	Maturity	0.95
270 to Harvest	Ripening	0.70

Accumulated ETc for a specified interval was taken as the water requirement of sugarcane and scheduled as depth of irrigation water. Restrictions of 12.5, 25.0 and 37.5 per cent were imposed on the full requirement based on full ETc, for formulating the treatments.

Treatments :

I_1 : Irrigation at 100 per cent ETc

I_2 : Irrigation at 87.5 per cent ETc

I_3 : Irrigation at 75.0 per cent ETc

I_4 : Alternate furrow irrigation at 75.0 per cent ETc

I_5 : Irrigation at 62.5 per cent ETc

I_6 : Alternate furrow irrigation at 62.5 per cent ETc

Evaporation related functions namely seasonal and daily ETc and crop evapotranspiration based on four empirical methods were worked out and the suitability was tested by correlation coefficients. Water use efficiency was estimated on cane and sugar yields basis and presented.

Results and Discussion

i. Seasoal and daily ETc

The seasonal ETc was estimated for the crop peiod and per day average ETc worked out during various growth phases of the cane for the respective treatments (Table. 1). Seasonal and total ETc was higher during special season than during main season. During both the seasons, gradual reduction in seasonal and daily ETc were observed with gradual lowering ETc in irrigation schedules. Methods of irrigation showed little variation in seasonal and daily ETc.

ii. Crop evaportranspiration (ETc)

Cone evapotranspiration for various growth phases were computed with Blaney - Criddle, Radiation, Penman and Pan evaporation methods and estimated through available soil moisture methods for both season crops. For scheduling irrigation based on Blaney - Criddle methods, ETc was worked out on the basis of thirty years mean climatic data. For evaluating various empirical methods including Blaney - Criddle method, the actual weather parameters that prevailed during the cropping period alone were considered.

The estimated ETc was 1223 and 1345 mm for main and special seasons, respectively. Crop evapotranspiration computed by Blaney - Criddle method was very closely correlated (r=0.704**) to the estimated ETc followed by pan evaporation method (r=0.7319**) during main sseason (Table2). However, during the special season ETc computed by the four empirical methods was highly correlated to the actual estimated ETc. The correlation co-efficients were 0.9354**, 0.8059**, 0.8742** and 0.8749** with Blaney - Criddle, Radiation, Penman ad Pan evaporation methods, respectively. ETc was higher during grand growth phases followed by formative phase.

iii. Water use efficiency

Field and crop water use efficiencies were influenced by irrigation schedules and weed management methods during both the seasons (Table 3).

Main Season : Higher irrigation schedules (I_1, I_2 and I_3) gave better crop water use efficiency (CWUE) than irrigation scheduled at lower ETc level (I_5). However, Field Water Use Efficiency (FWUE) amongst schedules of irrigation tried were comparable between themselves. No advantage was realised with alternater furrow irrigarion methods rather they tended to reduce WUE and was marked at the lowest regime tried.

Special Season : Reduced irrigation scheduled at 75 per cent ETc (I_3) gave higher CWUE as well as that of 75 per cent ETc (I_2) and at full ETC (I_1) had comparable CWUE as well as that of 75 per cent ETc in alternater furrow (I_4). Irrigation scheduled

at lower regime (62.5 per cent ETC) under both systems gave lower CWUE as compared to other regimes. Similarly, restricted irrigation scheduled at 75 per cent ETc either in normal or alternater furrow method and further reduced irrigation at 62.5 per cent ETc irrigating all furrows gave comparable FWUE. FWUE at other levels were lesser than at 75 per cent ETc.

For high WUE scheduling irrigation at 100 per cent ETc during germination and early tillering followed by at 75 per cent ETc during subsequent growth phases fo cane could be adopted. Climatological methods of predicting ETC and scheduling irrigation for sugarcane could be exploited for various agro climatic zones of Tamil Nadu for efficient water budgeting.

Reference

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Tabel -1. Irrigation schedules on seasonal and daily ETc (mm) in sugarcane.

Treatment	Main Season				Seasonal ETc (mm)	Special Season				
Irrigation Schedules	GEP 0-60 DP	FP 60-120 DP	GGP 12-240 DP	MRP 240-300 DP	TOTAL	GEP 0-60 DP	FP 60-120 DP	GGP 12-240 DP	MRP 240-300 DP	TOTAL
I_1 100% ETc	255.18	316.78	526.78	124.36	1223.10	247.36	233.26	659.38	205.70	1345.80
I_2 87.5% ETc	231.37	281.72	487.97	113.44	1114.50	231.21	229.49	392.20	185.30	1238.40
I_3 75% ETc	217.14	260.10	467.15	103.68	1048.10	209.96	221.30	529.04	175.80	1136.10
I_4 75% ETc Alt. Fur.	219.08	264.50	471.04	105.98	1060.60	217.05	220.95	545.70	175.30	1159.00
I_5 62.5% ETc	119.74	239.02	449.72	96.42	984.90	199.09	215.19	491.42	168.10	1073.80
I_6 62.5% ETc Alt. Fur.	206.40	244.56	456.72	99.62	1007.30	204.03	271.71	503.16	168.50	1093.40
Irrigation Schedules				Daily ETc (mm)						
I_1 100% ETc	4.25	5.28	4.39	2.07	4.08	4.12	3.89	5.49	3.43	4.49
I_2 87.5% ETc	3.86	4.71	4.07	1.89	3.72	3.82	3.82	4.94	3.09	4.13
I_3 75% ETc	3.62	4.34	3.89	1.73	3.49	3.69	3.69	4.41	2.93	3.79
I_4 75% ETc Alt. Fur.	3.65	4.41	3.93	1.77	3.54	3.68	3.68	4.55	2.92	3.86
I_5 62.5% ETc	3.33	3.98	3.75	1.62	3.28	3.59	3.59	4.10	2.81	3.58
I_6 62.5% ETc Alt. Fur.	3.44	4.08	3.81	1.66	3.36	3.63	3.63	4.19	2.81	3.65

Tabel -2. Computed seasonal ETc (mm) by various methods in sugarcane

Crop stage		Actual ETc	BCM	RM	PEM	PAM
		Main season				
GEP	0-60 DP	(4.25)	(3.27)	(3.09)	(3.47)	(3.19)
		255.18	190.07	185.12	208.30	191.32
FP	60-120 DP	(5.28)	(5.84)	(4.80)	(5.41)	(5.10)
		316.78	348.32	288.06	324.46	305.67
GGP	120-240 DP	(4.39)	(5.02)	(4.80)	(5.41)	(5.10)
		529.78	598.31	669.80	705.70	453.33
MRP	240-300 DP	(2.07)	(2.05)	(2.89)	(3.05)	(2.10)
		124.36	119.12	173.42	183.04	125.78
Total		(4.08)	(4.24)	(4.39)	(4.74)	(3.59)
		1223.10	1256.52	1216.40	1421.50	1076.10
r value			0.8704**	0.4769**	0.5542**	0.7319*
				Special season		
GEP	0-60 DP	(4.25)	(3.46)	(3.03)	(3.27)	(2.57)
		247.36	201.82	181.59	202.00	154.28
FP	60-120 DP	(3.86)	(3.70)	(4.67)	(4.83)	(2.92)
		233.26	220.88	280.27	289.64	175.26
GGP	120-240 DP	(5.49)	(6.29)	(6.86)	(6.85)	(5.31)
		659.38	751.70	823.04	822.06	636.66
MRP	240-300 DP	(3.43)	(4.21)	(4.05)	(4.30)	(3.53)
		205.7	248.50	243.30	258.10	211.80
Total		(4.49)	(4.79)	(5.09)	(5.25)	(3.93)
		1345.70	1422.90	1528.10	1571.80	1178.00
r value			0.9354**	0.8509**	0.8742**	0.8749**

Figures in paranthesis indicate per day ETc (mm)

GEP - Germination and Establishent Phase
FP - Formative Phase
RM - Radiation Method
PAM - Pan Evaporation Method
GGP - Grand Growth Phase
MRP - Maturity and Ripening Phase
BCM - Blaney - Criddle Method
PEM - Penman Method

Tabel -3. Irrigation schedules on water use efficiency in sugarcane.

Treatment	Main season				Special season			
	Cane(kg/ha cm^{-1}) yield		Sugar (kg/ha cm^{-1}) yield		Cane(kg/ha cm^{-1}) yield		Sugar (kg/ha cm^{-1}) yield	
	CWUE	FWUE	CWUE	FWUE	CWUE	FWUE	CWUE	FWUE
Irrigation Sechedules								
I_1 100% ETc	862	617	115	82	823	574	108	76
I_2 87.5% ETc	863	612	118	81	846	573	115	78
I_3 75% ETc	881	607	120	83	891	611	124	85
I_4 75% ETc Alt. Fur.	841	587	112	78	838	582	115	81
I_5 62.5% ETc	823	611	110	72	808	583	108	82
I_6 62.5% ETc Alt. Fur.	739	563	102	77	707	528	101	74
SEd	19	13	3.7	1.9	17	15	5.8	3.2
CD	42	28	8	4	38	34	13	7

CWUE - Crop Water Use Efficiency FWUE - Field Water Use Efficiency