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Crop coefficients of major crops of middle Gujarat region

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ABSTRACT

For the crops generally grown in the middle Gujarat (India) region, crop coefficients (Kc) for the different phenological phases were determined by computing the ratio of actual evapotranspiration (AET) from gravimetric lysimeter and pan evaporation (EP) from the standard USWB class -A pan evaporimeter. The Kc values for the whole crop growing season for the crops like tobacco, cotton, groundnut, wheat, maize,mustard, pigeonpea, bajra, cumin and greengram were 1.05, 1.15, 1.01, 1.35, 1.26, 0.79, 1.25, 0.54, 0.85 and 0.71, respectively. The particular phenophases of these crops having higher Kc values were identified as the critical stages for the water requirement of the crops. They are for tobacco: active growth stage(1.44), cotton: flowering to boll formation stage (1.64), groundnut: pegging stage (1.14), wheat: milking stage (1.21),maize: silking to dough stage (1.14), mustard: flowering to pod development stage (1.27), pigeonpea: flower bud initiation to 50% flowering (1.76), bajra: panicle to flag leaf stage (0.92), cumin: 50% flowering to 50% seed formation stage (1.6) and greengram: 50% flowering to 50% poddig (1.36), respectively.

Key words : Crop coefficients, Evapotranspiration, Phenophases,

Efficient water management is key to success in augmenting crop production. Increasing the irrigation water use efficiency necessitates improved irrigation scheduling techniques based on integrated effect of climate, soil, crop characteristics. Shekh *et al.* (1995) observed that evapotranspiration estimated by pan-evaporation method gave higher correlation with actual evapotranspiration determined through gravimetric lysimeters in groundnut. In the present study an attempt was made to determine the crop coefficient (Kc) values of different crops which have uitility in computation of water requirement of crops for irrigation scheduling.

MATERIALS AND METHODS

Lysimetirc data generated for different crops through two weighing type of lysimeters installed by India Meteorological Department at Anand (Latitude 22° 35' N; longitude 72° 55'E), Gujarat state have been used. The details regarding date of sowing and harvesting of crops are presented in Table 1. The same crop species were sown in both the lysimeters and averaged. Fertilizer application and plant protection measures were taken as per the recommended agronomic practices. The crops groundnut, maize, pigeonpea were grown under rainfed condition. Tobacco and cotton were grown under rainfed condition but with supplementary irrigation at the later growth stages. Mustard, summer bajra, cumin and mungbean crops were grown under irrigated conditions. Data on daily pan evaporation were also recorded from USWB class-A mesh covered pan evaporimeter installed in the meteorological observatory adjascent to the lysimeters. Crop coefficients (Kc) were

Table 1 : Details of crops grown in lysimeters

S.No	Crop	Variety	Date of sowing	Date of harvest
1.	Tobacco	Anand-119	07-09-79	18-02-80
	"	"	20-08-80	29-01-81
	"	"	18-08-81	23-01-82
2.	Cotton	H-6	27-07-82	26-02-83
	"	"	27-06-83	14-02-84
	"	"	30-05-84	02-03-85
3.	Groundnut	JL-24	20-06-86	18-10-86
	"	"	03-07-87	12-11-87
	"	"	07-07-88	19-11-88
4.	Wheat	Sonalika	20-11-77	06-04-78
	"	"	23-11-78	06-04-79
5.	Maize	Ganga S-2	11-07-89	11-10-89
	"	"	07-07-90	08-10-90
	"	"	27-07-91	03-11-91
6.	Mustard	Varuna F-9	09-11-90	07-03-91
	"	"	26-11-91	24-03-92
7.	Pigeonpea	GT-100	07-07-92	18-12-92
	"	"	29-06-93	14-12-93
	"	"	30-06-94	15-12-94
8.	Bajra	GHB-30	25-02-94	20-05-94
	"	"	04-02-95	11-05-95
9.	Cumin	GC-1	10-11-95	28-02-96
	"	"	10-11-96	03-03-97
10.	Greengram	GG-2	06-02-95	21-05-95
	"	"	15-02-96	10-05-96
	"	"	20-03-97	23-05-97
	"	"	04-03-98	13-05-98

determined by taking the ratio of actual evapotranspiration (AET) to pan evaporation (EP) throughout the crop growing season. Air temperature and relative humidity were also recorded simultaneously.

RESULTS AND DISCUSSION

Results on the seasonal crop coefficient (Kc) values and crop duartion (days) of different crops (Table 2) indicate that the Kc values of most of the crops have crossed the unit value (>1.0) during vegetative stages except in case of mustard, bajra and cumin crops. The long duration crops like cotton,pigeonpea and tobacco which were raised in the *kharif* season and continued upto winter season had experienced both humid and dry weather conditions. Respective seasonal cumulated actual evaportranspiration (AET) and corresponding pan evaporation (EP) values, mean air temperature and mean relative humidity are presented in Table 3. The AET values for the

Table 2 : Seasonal crop coefficients

Name of crop	crop coefficient (Kc)	crop duration (days)
Tobacco	1.05	160
Cotton	1.15	225
Groundnut	1.01	125
Wheat	1.35	130
Maize	1.26	95
Mustard	0.79	118
Pigeonpea	1.25	167
Bajra	0.54	94
Cumin	0.85	110
Greengram	0.71	78

Table 3 : Seasonal total evapotranspiration, evaporation and mean air temperature and relative humidity

Crop	Actual evapotranspiration (mm)	pan evaporation (mm)	Mean air temp. (°C)	Mean relative humidity (%)
Tobacco	667	632	24.6	65
Cotton	1000	864	26.5	70
Groundnut	635	595	28.0	72
Wheat	700	515	22.9	52
Maize	473	374	28.2	74
Mustard	365	457	21.1	55
Pigeonpea	819	654	27.1	69
Bajra	342	632	28.4	48
Cumin	363	425	22.4	57
Greengram	399	565	29.0	50

total crop growing seasons of the crops ranged from 342 mm for bajra to 1000 mm for cotton. Pan evaporation ranged from 374 mm for maize to 864 mm for cotton crop. The AET values of many of these crops were found to be very close to the seasonal water requirements of major crops of Gujarat region as determined by Sahu and Sastry (1993). The comparative low values of AET than EP for the crops like mustard, cumin and summer bajra might be due to low mean air temperature during winter season, low leaf area and moderate to severe dew deposition on crop canopy during major life span of cumin crop. Reduction in AET rate of bajra crop towards the later part of crop growth may be attributed to leaf and root senescence and also to increased resistance to water transport inside the leaf because of ageing (Rathore, 1986). In the present study it was observed that the AET of the *Kharif* crops like tobacco, cotton, pigeonpea etc. were highly influenced by the seasonal

Table 4 : Phenophase-wise crop coefficient (Kc) of different crops

Phenological stages	Crop coefficient (Kc)
Tobacco	
Establishment	0.92
Active growth	1.44
Topping	1.39
Spangle development	0.69
Cotton	
Vegetative	0.91
Flowering and boll formation	1.64
Picking	1.27
Maturity	0.71
Groundnut	
Emergence to flowering	0.65
Pegging	1.15
Pod development	0.85
Physiological maturity	0.55
Wheat	
Crown root initiation	0.81
Tillering to jointing	1.07
Flowering to heading	0.96
Milking	1.21
Dough	1.19
Physiological maturity	0.84
Maize	
Emergence to end of sixth leaf	0.71
Tassel emergence	0.82
Silk emergence	1.07
Dough stage	1.14
Physiological maturity	1.05
Mustard	
Vegetative phase	0.64
Flowering	1.18
Pod development	1.27
Physiological maturity	0.54
Pigeonpea	
Emergence to emergence of first trifoliate	0.71
Emergence of first trifoliate to emergence of primary branches	0.75
Emergence of primary branches to Emergence of secondary branches	0.93
emergence of secondary branches to Flower bud initiation	1.52
Flower bud initiation to 50% flowering	1.76
50% flowering to 50% podding	1.50
50% podding to physiological maturity	1.41
Bajra	
Emergence	0.54
Tiller initiation	0.40
Panicle initiation	0.64
Flag leaf stage	0.92
Booting stage	0.62
Half bloom stage	0.47
Milking stage	0.60
Physiological maturity	0.75
Cumin	
Emergence establishment	0.40
Initial vegetative	0.50
50% vegetative	0.68
Initial flowering	1.07
50% flowering	1.41
Initial seed formation	1.47
50% seed formation	1.60
Physiological maturity	0.75
Greengram	
Sowing to emergence	0.66
Emergence to first trifoliate	0.73
First trifoliate to flower bud initiation	0.61
Flower bud initiation to 50% flowering	0.75
50% flowering to 50% podding	1.36
50% podding to dough stage	0.72
Dough stage to Physiological maturity	0.43

weather changes (Table 2 ,3) as compared to their crop duration. The particular pheno phases of crops having higher values of Kc (Table 4) were identified as the critical stages for thier water requirement. The Kc values for such critical stages are : tobacco- active growth stage (1.44) ; cotton - flowering and boll formation (1.64), groundnut - pegging (1.15), wheat - milking (1.21), maize - silk to dough stage (1.14), mustard - flowering to pod development (1.27), pigeonpea - flower bud initiation to 50% flowering (1.76),bajra -panicle to flag leaf stage (0.92) and cumin - 50% flowering to 50% seed formation stage (1.60), respectively. Similar results were reported in maize crop (Patel *et al.*, 1994 ; Ganeshan *et al.*, 1986), in groundnut (Shekh *et al.*, 1995), in mustard (Savani *et al.*, 1994), in bajra and wheat (Rao *et al.*, 1989), in pigeonpea (Patel *et al.*, 1996), respectively. Looking to the phenophase-wise values of the crop coefficients of different crops, it was observed that the period between flowering to initial fruiting were the most sensitive to water requirement. The utilization of water by the plants at these phases remained very high due to high transpiration with the plant canopy having maximum LAI at this stage (Patel *et al.*, 1991). Relatively higher Kc values in respect of pigeonpea and cumin crops needs further examination from energy exchange conditions with the surrroundings.

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