Phase IX Status Report

On

Crop K_c, Water Requirement of *kharif* Sesame along with Suitable Shading Factors with different Irrigation Practices

in

"Determination of Crop Coefficients for Major Crops by Lysimetric Studies"

at

Mahatma Phule Krishi Vidyapeeth, Rahuri

Submitted to

Nanaji Deshmukh Krushi Sanjeevani Prakalp (PoCRA), Mumbai

Title of the project	:	Determination of Crop Coefficients for Major Crops by Lysimetric Studies
Location	:	CAAST-CSAWM Climate Smart Research Block and Experimental Field of AICRP on IWM, Mahatma Phule Krishi Vidyapeeth, Rahuri
Duration	:	2020-2024
Total Outlay	:	Rs. 31.43 Lakhs (Rs. Thirty one lakh fourty three thousand only)
Principal Investigator	:	Dr. A. A. Atre, Professor and Head, Deptt. of SWCE, Dr. ASCAE&T, MPKV, Rahuri
Co-Principal Investigator	:	Dr. M. G. Shinde, Professor of SWCE, Dept. of Agril. Engg., MPKV, Rahuri
	:	Dr. S. A. Kadam, Associate Professor of IDE, Dept. of Agril. Engg., MPKV, Rahuri
Coordinator for the project for three universities (MPKV, Rahuri; Dr. PDKV, Akola and VNMKV, Parbhani)	:	Dr. S. D. Gorantiwar, Director of Research and Head, Dept. of Agril. Engg., MPKV, Rahuri

1. Introduction

The Project is being executed at Mahatma Phule Krishi Vidyapeeth, Rahuri. This project is undertaken for determination of crop coefficients of *kharif* Sesame, *rabi* Gram and Summer Fodder Bajra. In the second year experiment of *kharif* season, Sesame was sown on 8th July, 2023 in three Lysimeters and surrounding area of 1.0 ha. The details of Sesame variety 'Phule Purna (JLT 408)'; sown for the experiment are given in Table 1.

Table 1. Details of *kharif* Sesame Crop.

Common Name	Sesame
Scientific Name	*Sesamum indicum L.*
Variety	Phule Purna (JLT 408)
Release year	2010
Name of Institute / University	Mahatma Phule Krishi Vidyapeeth, Rahuri
Crop Spacing	30 × 10 cm
Soil type requirement	Medium Soil to Black Soil
Climate requirement	Rainfed, Temperature: 21 to 26^{o}C during growth period and 26 to 32^{o}C during seed filling period
Seed Rate	1 to 1.2 kg/ha
Productivity	7.8 q/ha
Characters / features	• White and bold seed, • High oil content (53.2%), • Low in free fatty acid (1.46%), • High Iodine value (107), • Moderately resistant to Phyllody, Cercospora,

2. Estimation of Reference Crop Evapotranspiration (ET_r) by Penman-Monteith Method

Reference crop evapotranspiration (ET_r) during the crop growing season is estimated by using the Penman-Monteith Method [Eq (1)].

$$ET_r = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)} \quad \ldots (1)$$

Where,

ET_r = Reference evapotranspiration [mm/day],

R_n = Net radiation at the crop surface [MJ/ m^2 day],

G = Soil heat flux density [MJ/ m^2 day],

T = Mean daily air temperature at 2 m height [°C],

u_2 = Wind speed at 2 m height [m/ s],

e_s = Saturation vapour pressure [kPa],

e_a = Actual vapour pressure [kPa],

e_s - ea = Saturation vapour pressure deficit [kPa],

Δ = Slope vapour pressure curve [kPa/ °C],

g = Psychrometric constant [kPa / °C].

The daily variation of ET_r during crop growing season of Sesame is shown in Figure 1. Values of reference evapotranspiration during the crop growing season (08-07-2023 to 04-10-2023) varied from 2.2 to 5.09 mm with average ETr of 3.39 mm.

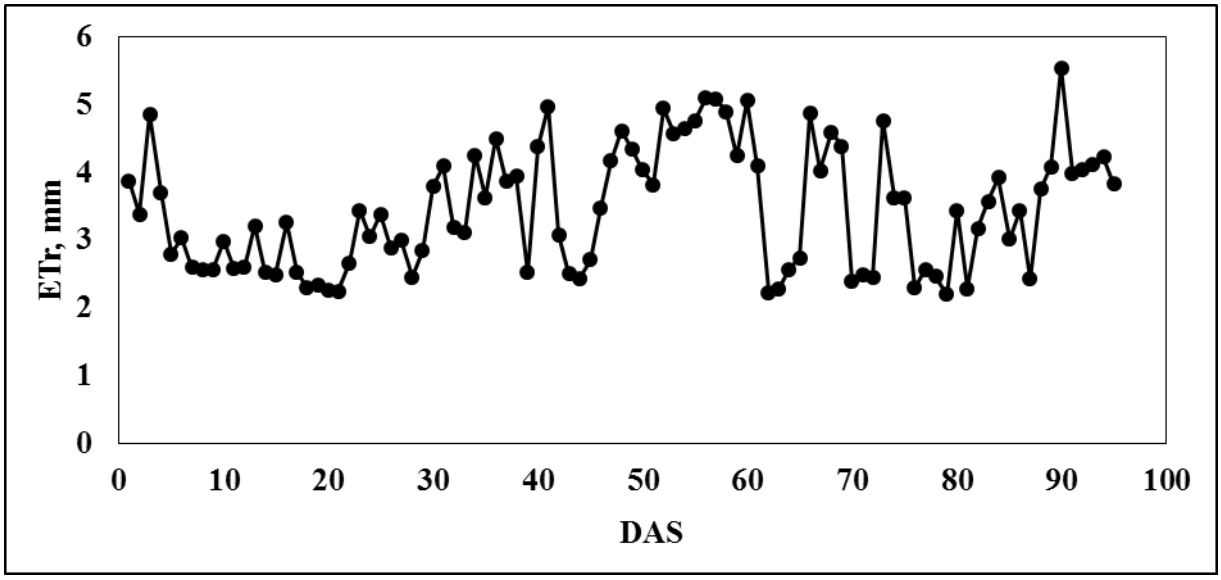

Figure 1: Daily variation of ETr during crop growth period of Sesame

3. Crop Evapotranspiration of Sesame

Lysimeter is used to measure crop evapotranspiration where the crop is grown in isolated tanks filled with soil. Weighing Lysimeters measure crop water used by measuring the change in mass of an isolated volume of soil. Irrigation and precipitation add water and increase the weight of the soil volume and drainage and evapotranspiration removes water and decrease the weight. Water input and output is measured by Water Balance Method and then crop evapotranspiration is calculated using water balance method [Eq. (2)].

$$ETc = P + I - \Delta S - D \quad \ldots (2)$$

Where,

ET_c = Crop Evapotranspiration, mm;

P = Precipitation, mm;

I = Irrigation, mm;

ΔS = Change in water storage, mm;

D = Drainage, mm.

Daily variation of crop evapotranspiration (mm) of Sesame is shown in Figure 2.

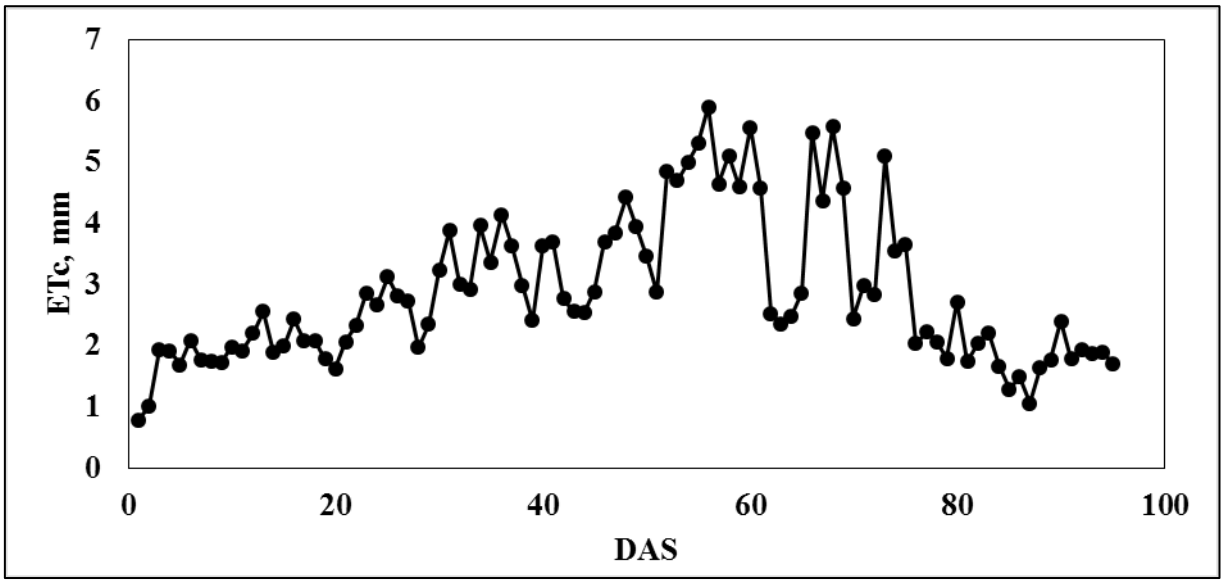

Figure 2: Daily variation of ETc during crop growth period of Sesame

4. Crop Coefficient of Sesame and development of Kc curve

The daily Kc values were estimated for Sesame as the ratio of crop evapotranspiration (ETc) to the reference evapotranspiration (ETr) estimated by Penman-Monteith method over crop growth period using Eq (3).

$$K_c = ET_c / ET_r \quad \ldots (3)$$

Where,

K_c = Crop Coefficient

ET_c = Crop Evapotranspiration

ET_r = Reference Crop Evapotranspiration

The polynomial equations of second, third, fourth and fifth orders are fitted to calculate daily K_c, with K_c as the dependent variable and (t/T) as the independent variable. The best fit polynomial equation is selected based on maximum R^2.

The different forms of second, third, fourth and fifth order polynomial equation are as below:

$$Kc_t = a_o\left(\frac{t}{T}\right)^0 + a_1\left(\frac{t}{T}\right)^1 + a_2\left(\frac{t}{T}\right)^2$$

$$Kc_t = a_o\left(\frac{t}{T}\right)^0 + a_1\left(\frac{t}{T}\right)^1 + a_2\left(\frac{t}{T}\right)^2 + a_3\left(\frac{t}{T}\right)^3$$

$$Kc_t = a_o\left(\frac{t}{T}\right)^0 + a_1\left(\frac{t}{T}\right)^1 + a_2\left(\frac{t}{T}\right)^2 + a_3\left(\frac{t}{T}\right)^3 + a_4\left(\frac{t}{T}\right)^4$$

$$Kc_t = a_o\left(\frac{t}{T}\right)^0 + a_1\left(\frac{t}{T}\right)^1 + a_2\left(\frac{t}{T}\right)^2 + a_3\left(\frac{t}{T}\right)^3 + a_4\left(\frac{t}{T}\right)^4 + a_5\left(\frac{t}{T}\right)^5$$

Where,

Kc_t = Crop Coefficient of t^{th} day.

a_0, a_1, a_2…..= Constants of equations.

t = Day considered after sowing.

T = Total crop growth period from sowing to harvesting (days)

Figure 3 shows the Kc curve along with polynomial equation of third order having R^2 of 0.76 fitted to estimate Kc values. Daily Kc values derived by using this polynomial equation [Eqn. (4)] are given in the Appendix – A.

$$K_{ct} = -5.1222(t/T)^3 + 4.6466(t/T)^2 + 0.0307(t/T) + 0.4752 \quad \ldots..(4)$$

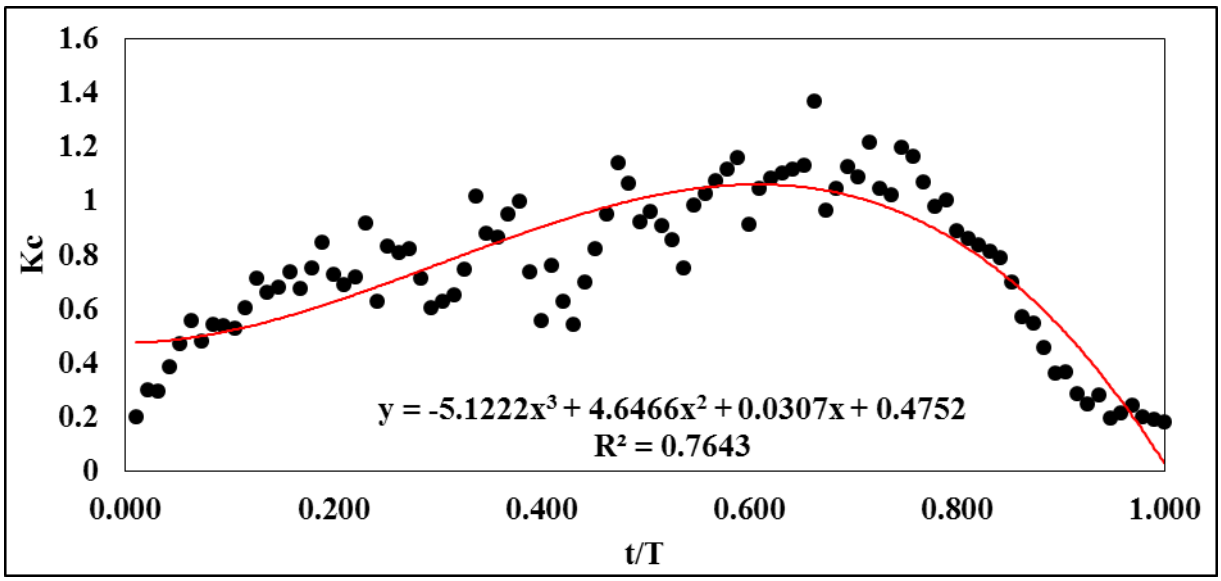

Figure 3. Kc curve for Sesame

5. Estimation of weekly crop coefficient and crop water requirement

Weekly Kc and crop water requirement (mm) are given in Table 2 and stage wise Kc values are given in Table 3.

Table 2: Weekly Crop Coefficients and crop water requirement (mm) of Fodder Bajra at Rahuri

CW	ETr (mm)	ETc (mm)	Kc
1	24.2	11.8	0.49
2	19.0	10.2	0.53
3	17.4	10.7	0.61
4	20.8	14.9	0.71
5	24.9	20.3	0.82
6	27.2	25.0	0.92
7	24.2	24.2	1.00
8	31.8	33.4	1.05
9	27.8	29.4	1.06
10	25.5	25.8	1.01
11	21.8	19.5	0.89
12	21.0	14.7	0.70
13	26.2	10.9	0.42

Table 3: Stage wise Kc values of *kharif* Sesame

Stage	Duration	Local Kc	FAO – 56 Kc
Initial	20	0.53	0.35
Development	25	0.82	0.74
Mid	35	0.98	1.10
End	15	0.39	0.25

6. Irrigation water requirement using locally derived Kc values for Sesame for Western Maharashtra Region

To calculate crop and irrigation water requirement of Sesame using weekly K_c values for western Maharashtra, meteorological data for 22 Agricultural Research Stations was used for estimation of reference crop evapotranspiration by Hargreaves - Samani Method. As the data of minimum and maximum temperature were available for all these stations (Table 4). Reference evapotranspiration was calculated by using Phule Jal with minimum and maximum temperature and latitude of these stations as input parameters.

After the calculations of reference evapotranspiration for 22 weather stations, weekly values were interpolated over entire Western Maharashtra by Inverse Distance Weight (IDW) method using ArcMap which were then multiplied by respective crop coefficients obtained from Lysimetric Studies. As a result, weekly maps of crop water requirement were developed for Western Maharashtra from which taluka wise weekly crop water requirement was extracted using Geo-statistical Analysis tool in ArcMap. As Sesame is close growing row crop, the shading factor is considered as 1 while calculating crop water requirement.

Taluka wise weekly crop water requirement is converted into irrigation water requirement for surface irrigation by considering 40, 50 and 60 per cent efficiency, by sprinkler irrigation 80 and 85 per cent efficiency and by drip irrigation 90 and 95 per cent efficiency. Taluka wise crop water requirement and irrigation water requirement of 10 districts of Western Maharashtra *Viz*. Ahmednagar, Dhule, Jalgaon, Kolhapur, Nandurbar, Nashik, Pune, Sangli, Satara and Solapur are given in Appendix-B.

Table 4: List of Agricultural Research Station for which meteorological data was obtained

Sr. No.	Zone	Name of Agricultural Research Station and Location
1.	Western Ghat Zone	Zonal Agricultural Research Station, Igatpuri Dist. Nashik
2.		Agricultural Research Station, Lonavala Dist. Pune
3.		Agricultural Research Station, Radhanagari, Dist. Kolhapur
4.		Regional Wheat Rust Research Station, Mahabaleshwar, Dist. Satara
5.	Sub-Montane Zone	Zonal Agricultural Research Station, Shenda Park, Kolhapur
6.		Agricultural Research Station, Karad
7.		Agricultural Research Station, Vadgaon Maval
8.		Agricultural Research Station, Gadhinglaj
9.	Plain Zone	Zonal Agricultural Research Station, Ganeshkhind, Pune
10.		Agriculture Research Station Niphad, Dist. Nashik
11.		Agriculture Research Station Kasbe Digraj, Dist. Sangli
12.		Agriculture Research Station, Pimpalgaon Baswant, Dist. Nashik
13.		College of Agriculture, Pune
14.	Scarcity Zone	Zonal Agriculture Research Station, Solapur
15.		Central Sugarcane Research Station, Padegaon
16.		Agriculture Research Station, Mohol
17.		Pulse and Oilseed Research and Training Center, Pandharpur
18.		Agriculture Research Station, Jeur
19.		Agriculture Research Station, Savalvihir
20.		Agriculture Research Station, Chas
21.		Agriculture Research Station, Dhule
22.	Central Plateau Zone	Oil Seed Research Station, Jalgaon

7. Photographs taken during experiment (08-07-2023 to 11-10-2023).

Sesame Crop at Initial Growth Stage

Sesame Crop at Development Stage

Sesame Crop at the time of flowering

Field view

Sesame Crop at the time of harvesting

8. Yield Data of Sesame

The production of Sesame was produced is 20.3 kg from Lysimeter and surrounding area. The Sesame produced was provided to AICRP on IWM in gratis.

9. Expenditure statement till 31st January, 2024

Table 5: Expenditure statement till 31st January, 2024

Sr. No.	Head wise Expenditure	Amount, Rs.
1.	**Human Resources**	
a)	SRF	5,82,890/-
b)	Field Assistant	2,19,944/-
	Subtotal	**8,02,834/-**
2.	**Recurrent Expenditure**	
a)	Farm input	1,43,288/-
b)	Travelling	14,760/-
c)	Stationery and other contingencies	48,731/-
d)	Contractual labours	2,49,521
	Subtotal	**4,56,300/-**
	Total expenditure till 31st January, 2024	**12,59,134/-**
	Released Grant	**19,84,743/-**

Appendix – A

Daily K_c Values for *kharif* Sesame Derived from Kc Curve

DAS	Kc	DAS	Kc	DAS	Kc	DAS	Kc
1	0.476	26	0.727	51	1.038	76	0.851
2	0.478	27	0.742	52	1.044	77	0.825
3	0.481	28	0.757	53	1.049	78	0.798
4	0.484	29	0.772	54	1.053	79	0.768
5	0.489	30	0.787	55	1.056	80	0.737
6	0.494	31	0.802	56	1.059	81	0.704
7	0.501	32	0.817	57	1.060	82	0.670
8	0.508	33	0.832	58	1.060	83	0.633
9	0.515	34	0.847	59	1.059	84	0.594
10	0.524	35	0.861	60	1.058	85	0.554
11	0.533	36	0.875	61	1.055	86	0.511
12	0.543	37	0.889	62	1.051	87	0.466
13	0.553	38	0.903	63	1.045	88	0.419
14	0.564	39	0.917	64	1.039	89	0.370
15	0.576	40	0.930	65	1.031	90	0.319
16	0.588	41	0.942	66	1.022	91	0.266
17	0.600	42	0.954	67	1.011	92	0.211
18	0.613	43	0.966	68	0.999	93	0.153
19	0.626	44	0.977	69	0.986	94	0.093
20	0.640	45	0.988	70	0.971	95	0.030
21	0.654	46	0.998	71	0.955		
22	0.668	47	1.007	72	0.938		
23	0.682	48	1.016	73	0.918		
24	0.697	49	1.024	74	0.898		
25	0.712	50	1.032	75	0.875		