

Status Report V

Estimation of crop Kc, water and irrigation requirement of Kharif Soybean and Greengram crop using lysimetric studies

Title of the project	:	Determination of crop coefficients for major crops by Lysimetric studies” at Vasantao Naik Marathwada Krishi Vidyapeeth Parbhani.
Location	:	Department of Irrigation & Drainage Engineering, College of Agricultural Engineering Research Field, Vasantao Naik Marathwada Krishi Vidyapeeth Parbhani
Duration	:	Three years
Total outlay	:	Rs. 38.38 lakhs
Investigators	:	
Principal Investigator	:	Dr. U. M. Khodke Associate Dean & Principal College of Agricultural Engineering & Technology VNMKV Parbhani
Co-Principal Investigators	:	1) Dr. H.W. Awari Head, Deptt. of Irrigation & Drainage Engineering, CAET, VNMKV Parbhani 2) Dr. V.K. Ingle Assistant Professor, Deptt. of Irrigation & Drainage Engineering, CAET, VNMKV Parbhani
Coordinator for the project		Dr. S.D. Gorantiwar PI CAAST-CSAWM and Head, Deptt. of Agril. Engg., MPKV, Rahuri

1. Introduction

This Project is being executed at Vasantao Naik Marathwada Krishi Vidyapeeth, Parbhani. Following activities were undertaken for estimation of crop Kc, water and irrigation requirement for *Kharif* Soybean and Greengram crop using lysimetric studies.

1.1 Details of work

The field experiment was planned to determine the crop coefficient of *Kharif* Soybean and Greengram crop using Lysimeter. The sowing of Soybean (MAUS-612) and Greengram (BM-2003-2) crop was done on 20th June 2022 respectively. The seed treatment for *Kharif* Soybean and Greengram seed was under taken with Rizofos @100 ml per 10kg seed. Table 1 and 2 shows various details of sown variety of Soybean (MAU-612) and Greengram (BM-2003-2) respectively.

Table 1: Details of sown variety of Soybean (MAUS-612)

Scientific Name	Glycine max
Variety	MAUS-612
Release year	2016
Name of University	Vasantao Naik Marathwada Krishi Vidyapeeth, Parbhani
Soil type	Well drained, medium to heavy soils
Climate	Minimum Temperature 15-20 ⁰ C, Maximum temperature 30-35 ⁰ C
Sowing Time	15 th June to 10 th July Duration :93-98 days
Seed rate	75kg/ha
Productivity	30-35 q/ha
Characters/features	Pods do not fall 10-15 days after ripening, well resistant for diseases and resistant to low moisture

Table 2: Details of sown variety of Greengram (BM-2003-2)

Scientific Name	Vigna radiata
Variety	BM-2003-2
Release year	2010
Name of University	Vasantao Naik Marathwada Krishi Vidyapeeth, Parbhani
Soil type	Soil with 6.50 to 7.50 ph, Well drained, medium to heavy soils
Climate	Minimum temperature 21-24 ⁰ C
Sowing Time	Last week of June to first week of July
Seed rate	15 kg/ha
Duration	65-70 days
Productivity	8-10 q/ha
Characters/features	Bold and shiny seed. Erect growth habit. Long pod.

1.2 Experimental activity photo



Plate 1: Growing of Soybean crop in lysimeter



Plate 2: Inspection of flowering stage of Soybean



Plate 3: Visit the field with students



Plate 4: Growing of Greengram crop in lysimeter



Plate 5: Flowering stage of Greengram crop



Plate 6: Visit of Principal Investigator Dr. U.M.Khodke, Dr. H.W.Awari and Dr. V. K. Ingle



Plate 7: Observation of growth of Greengram

2. Crop Protection Measures for *Kharif* Soybean and Greengram

In order to protect the crop from different agents including pests, weeds, plant diseases and other organism, the various insecticide, fungicide and weedicide were used for spraying on *Kharif* Soybean and Greengram. Following is the schedule of spraying of pesticide, insecticide, fungicide during growth period of *Kharif* Soybean and Greengram crops.

Table 3: Crop Protection Measures in *Kharif* Soybean and Greengram

Sr.No	Date of Application	Insecticide/Fungicide/Pesticide	Quantity
1	24/06/2022	Strongarm (Diclosulam 84% WDG)	12.4gm / acre
2	27/06/2022	Meera-71(Ammonium salt of glyphosate 71% SG)	60gm / 10lit water
3	13/07/2022	Topper 77 (Glyphosate 71% SG)	1200gm / acre
4	19/08/2022	Tata Jashn Super (Profenofos 40% + Cypermethrin 4% E.C)	25ml / 10 lit water
5	10/09/2022	Ampligo (Chloratranilprole 10% + Lambdacyhalothrin 5% ZC)	100ml / acre

3. Estimation of Crop Coefficient (Kc) and Reference Evapotranspiration (ETr)

Crop coefficients (Kc) is the ratio of crop evapotranspiration (ETc) to reference crop evapotranspiration (ETr) as given by following equation:

$$Kc = \frac{ETc}{ETr} \dots\dots (1)$$

The weekly values of crop coefficients were computed as the ratio of weekly crop evapotranspiration and reference evapotranspiration. Weekly crop evapotranspiration data was obtained from the lysimeters by growing the crop in lysimeters. Two lysimeters was used for this purpose and the crop evapotranspiration values were measured for both the lysimeters and the ETc values were averaged over both the lysimeters to avoid errors in measurements. Penman Monteith method was used to estimate the reference crop evapotranspiration.

3.1 Penman Monteith Method

Performance of various estimation methods revealed the need for formulating a standard method for the computation of ETo. The FAO Penman-Monteith method has been recommended as the sole standard method for estimation of ETo. It is a method with strong likelihood of correctly predicting ETo in a wide range of locations (Allen et al., 1998). By defining the reference crop as a hypothetical crop with an assumed height of 0.12 m having a surface resistance of 70 s m⁻¹ and an albedo of 0.23, closely resembling the evaporation of an extension surface of green grass of uniform height, actively growing and adequately watered. FAO Penman-Monteith method uses following equation for estimation of ETo.

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T + 273} u(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)} \dots\dots\dots (2)$$

Where,

- ET_O - reference evapotranspiration (mm day⁻¹),
- R - net radiation at the crop surface (MJ m⁻² day⁻¹),
- G - soil heat flux density (MJ m⁻² day⁻¹),
- T - mean daily air temperature at 2 m height (°C),
- u₂ - wind speed at 2 m height (m s⁻¹),
- e_s - saturation vapour pressure (kPa),
- e_s - actual vapour pressure (kPa),
- e_s - e_a - saturation vapour pressure deficit (kPa),

- Δ - slope vapour pressure curve (kPa °C⁻¹),
 γ - psychrometric constant (kPa °C⁻¹).

Phule Jal mobile app, developed by the Mahatma Phule Krishi Vidhyapeeth, Rahuri under the RKVY project on Irrigation Water Requirement Service was used for the estimation of the reference crop evapotranspiration by the Penman Monteith method.

4. Crop Coefficients (Kc) for *Kharif* Soybean

Crop coefficient is defined as the ratio of crop evapotranspiration to the reference crop evapotranspiration. Factors affecting Kc include crop type, crop growth stage, climate, soil moisture. Kc is normally expressed as a function of time. Steps for computing of Kc include determination of total growing period of the crop and determination of Kc values for each growth stage. The growing period was divided into four distinct growth stages; initial, development, mid and late-season.

4.1 Actual crop evapotranspiration (ETc)

Actual evapotranspiration under standard conditions denoted as ETc is the evapotranspiration under optimum soil water conditions and achieving full production under the given climatic conditions. The meteorological week wise evapotranspiration of *Kharif* Soybean is estimated and presented in Table 4. The mean actual evapotranspiration of *Kharif* Soybean was recorded between 1.6 to 6.1 mm. From the Table 4, it is found that crop water needs are generally low during the initial growth stages but increases exponentially during the vegetative phases and then again decreases during flowering and fruiting stages.

4.2 Reference evapotranspiration (ETo)

Reference evapotranspiration (ETo) is commonly computed from weather data since, the direct measurements are often expensive. The daily ETo estimated using meteorological data was converted into week wise reference evapotranspiration. Weekly estimation of reference evapotranspiration (ETo) is presented in Table 4. Data presented in Table 4 show that ETo ranges from 2.9 to 6.1 mm/day for *Kharif* Soybean. Reference evapotranspiration increased with respect to change in climate.

Fig.1 represents comparative performance of week wise recorded actual evapotranspiration (ETc) and reference evapotranspiration (ETo) *Kharif* Soybean.

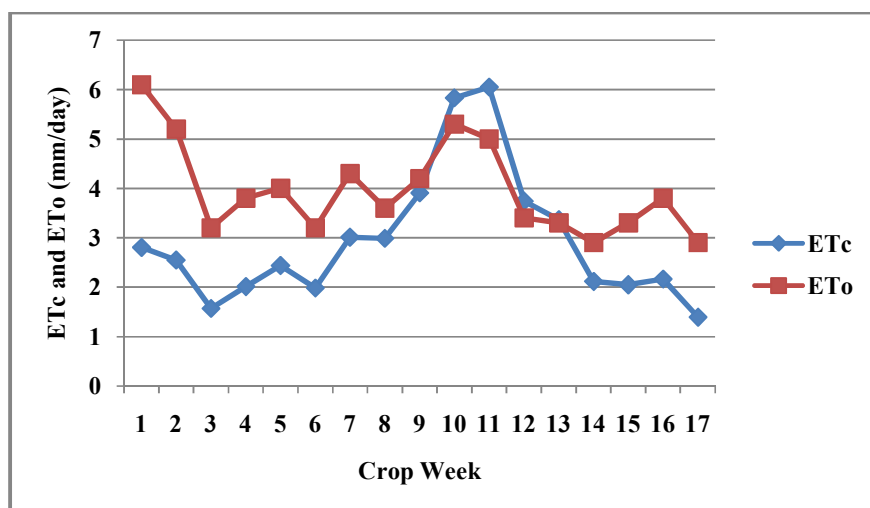


Fig. 1 : Comparative performance of week-wise recorded ETc(mm/day) and ET0 (mm/day) during experimentation for Kharif Soybean

The computed Kc values for Kharif Soybean during initial, development, mid and end stages were 0.49, 0.67, 1.04 and 0.57, respectively. The maximum Kc value was found during mid season stage and lowest was found during initial stages. Fig. 2 represents the weekly lysimetric Kc curve during crop growth period of Kharif Soybean.

Data presented in Table 4 represents weekly lysimetric crop coefficient values for Kharif Soybean.

Table 4: Weekly lysimetric crop coefficient (Kc) values for Kharif Soybean

Crop Week	ETc (mm/day)	ET ₀ (mm/day)	Kc (L1)	Kc(L3)	Average Kc	Crop Growth stages	Stage wise Kc values
1	2.8	6.1	0.46	0.48	0.47	Initial (20 Days)	0.49
2	2.5	5.2	0.49	0.50	0.50		
3	1.6	3.2	0.49	0.50	0.50		
4	2.0	3.8	0.53	0.56	0.55	Development (35 days)	0.67
5	2.4	4.0	0.61	0.63	0.62		
6	2.0	3.2	0.62	0.65	0.64		
7	3.0	4.3	0.70	0.75	0.73		
8	3.0	3.6	0.83	0.86	0.85	Mid (45 days)	1.04
9	3.9	4.2	0.93	0.97	0.95		
10	5.8	5.3	1.10	1.15	1.13		
11	6.1	5.0	1.21	1.25	1.23		
12	3.7	3.4	1.10	1.15	1.13		

13	3.4	3.3	1.02	1.07	1.05		
14	2.1	2.9	0.73	0.76	0.75		
15	2.0	3.3	0.62	0.65	0.64	End (15days)	0.57
16	2.2	3.8	0.57	0.6	0.59		
17	1.4	2.9	0.48	0.52	0.50		

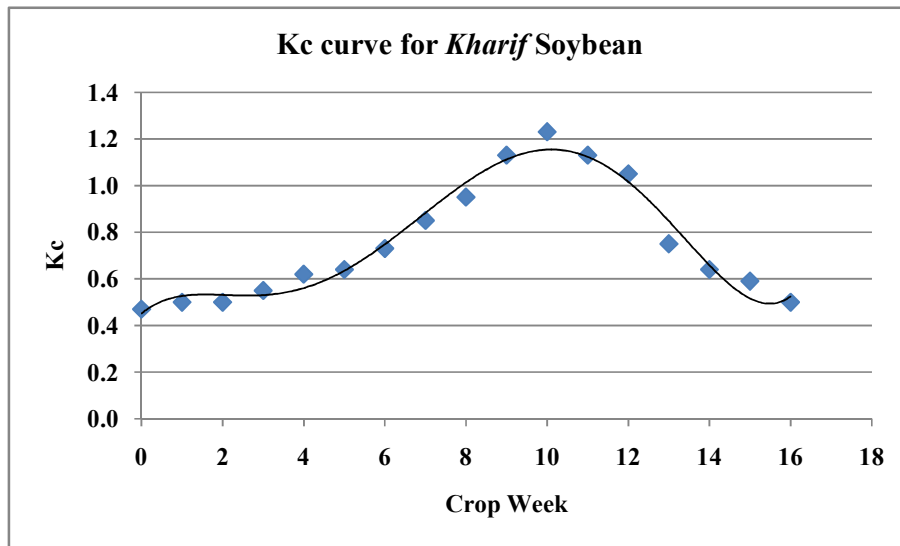


Fig. 2: Weekly lysimetric Kc curve of *Kharif* Soybean during crop growth period

5. Crop Coefficients (Kc) for *Kharif* Greengram

Crop coefficients (Kc) are properties of plants used in predicting evapotranspiration. The Kc values represent the crop type and the development of the crop. For *Kharif* Greengram, one lysimeter (L2) was used to calculate crop coefficient value (Kc).

5.1 Actual crop evapotranspiration (ETc)

The daily actual evapotranspiration (ETc) was converted to average mean value of evapotranspiration for every meteorological week during the crop growth period. The meteorological week wise evapotranspiration of *Kharif* Greengram is estimated and presented in Table 5. The mean actual evapotranspiration of *Kharif* Greengram was recorded between 1.4 to 4.9 mm. From the Table 5, it is found that crop water requirement was lowest during initial stages and highest during mid-stage of crop growth period.

5.2 Reference evapotranspiration (ET_o)

The daily reference evapotranspiration was converted into week wise average reference evapotranspiration (Table 5). Data presented in Table 5 show that ET_o ranges between 2.9 mm to 6.1 mm/day for *Kharif* Greengram. The maximum reference evapotranspiration was recorded in month of June. Fig. 3 represents comparative performance of week wise recorded actual evapotranspiration (ET_c) and reference evapotranspiration (ET_o) *Kharif* Greengram.

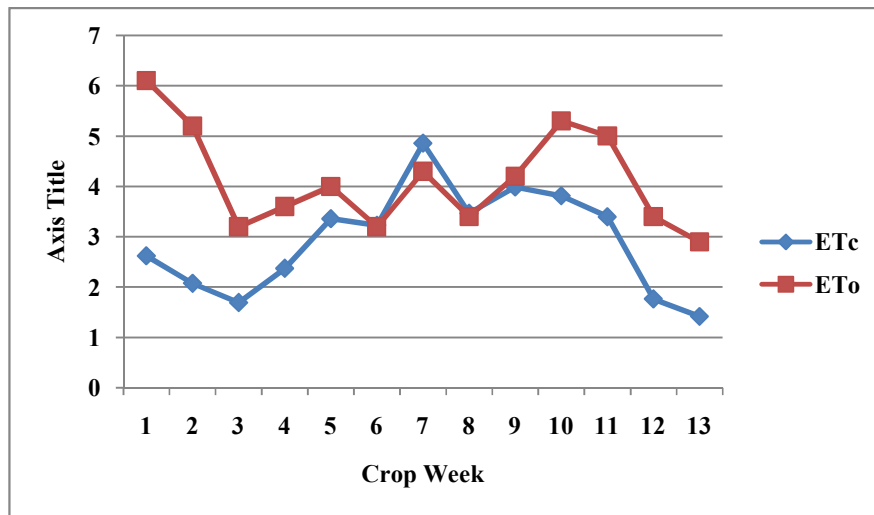


Fig. 3: Comparative performance of week-wise recorded ET_c(mm/day) and ET_o (mm/day) during experimentation for *Kharif* Greengram

The computed K_c values for *Kharif* Greengram during initial, development, mid and end stages were 0.45, 0.91, 0.68 and 0.51 respectively. The maximum K_c value was found during mid season stage and lowest was found during initial stages. Fig. 4 represents the weekly lysimetric K_c curve during crop growth period of *Kharif* Greengram.

Data presented in Table 5 represents weekly lysimetric crop coefficient values for *Kharif* Greengram.

Table 5: Weekly lysimetric crop coefficient (Kc) values for *Kharif* Greengram

Crop Week	ETc (mm/day)	ET ₀	Weekly Kc by lysimeter 3	Crop Growth stages	Stage-wise Kc values
1	2.6	6.1	0.43	Initial (15 Days)	0.45
2	2.1	5.2	0.40		
3	1.7	3.2	0.53		
4	2.4	3.6	0.66	Development (25 days)	0.91
5	3.4	4	0.84		
6	3.2	3.2	1.01		
7	4.9	4.3	1.13		
8	3.5	3.4	1.02	Mid (25 days)	0.68
9	4.0	4.2	0.95		
10	3.8	5.3	0.72		
11	3.4	5	0.68		
12	1.8	3.4	0.52	End (10days)	0.51
13	1.4	2.9	0.49		

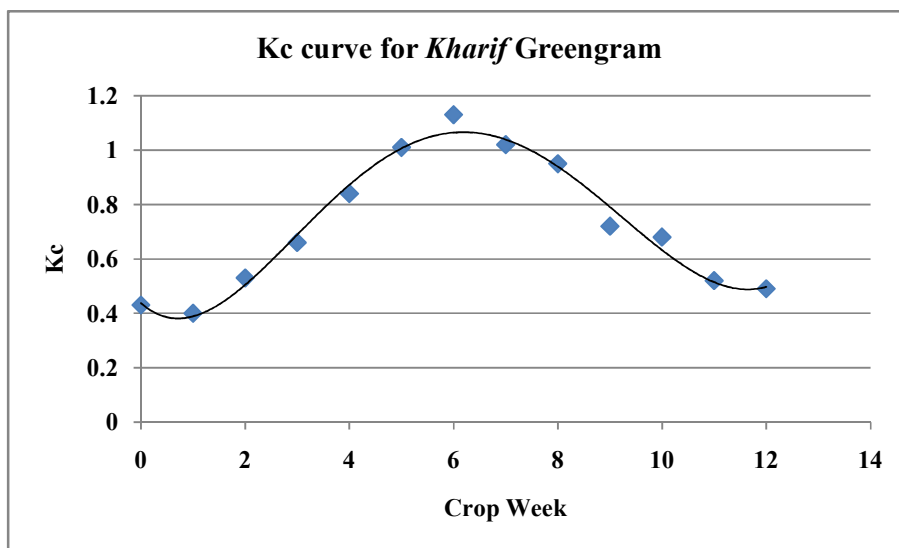


Fig. 4: Weekly lysimetric Kc curve of *Kharif* Greengram during crop growth period

6. Yield data of *Kharif* Soybean

Table 6: Yield of *Kharif* Soybean in Lysimeter 1&3 and field plots

Particular	Production	Yield per unit area
Lys.1	621 gram	27.60 q/ha
Lys.3	598 gram	26.57 q/ha
Field Plot	489 gram	21.73 q/ha

7. Yield data of *Kharif* Greengram

Table 7: Yield of *Kharif* Greengram in Lysimeter 2 and field plots

Particular	Production	Yield per unit area
Lys.2	267 gram	26.70 q/ha
Field Plot	245 gram	24.50 q/ha

8. Irrigation water requirement using lysimetric Kc values for *Kharif* Soybean and Greengram for Marathwada region

In present, the estimation of crop Kc (lysimetric), water and irrigation requirement by different irrigation practices for *Kharif* Soybean and Greengram based on lysimetric Kc was calculated for ignoring effective rainfall by Surface irrigation at 60, 50 and 40%, Sprinkler irrigation at 85 and 80%; and Drip irrigation at 95 and 90% system efficiency for all tehsils of Marathwada region. The details of talukawise irrigation water requirement for *Kharif* Soybean and Greengram are given in **Annexure I and II** respectively.

Investigators:

Dr. V. K. Ingle Co-Principal Investigator :



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