

Status Report VIII

Estimation of second year 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 Vasantnao Naik Marathwada Krishi Vidyapeeth Parbhani.
Location	:	Department of Irrigation & Drainage Engineering, College of Agricultural Engineering Research Field, Vasantnao 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 second year 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 Soyabean (MAUS-612) was done on 9st July 2023 while sowing of Greengram (BM-2003-2) was on 1th July 2023. The seed treatment for *Kharif* Soybean and Greengram seed was under taken with Rizofos @100 ml per 10 kg 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	Min Temperature 15-20 ⁰ C, Max 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	Min 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: Sowing of Soybean crop in lysimeter



Plate 2: Flowering stage of Soybean



Plate 3: View of Soybean Growth in lysimeter



Plate 4: Field view of Soybean



Plate 4: Inspection of Greengram growth in lysimeter



Plate 4: Field view of Greengram



Plate 5: Greengram crop growth at Pod filling stage



Plate 6: Visit of Dr. U.M. Khodke, PI along with CO-PI Dr. H.W.Awari and Dr. V. K. Ingle

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

Sr. No	Date of Application	Insecticide/Fungicide/Pesticide	Quantity
1	08/07/2023	Strongarm (Diclosulam 84% WDG)	12.4gm / acre
2	02/08/2023	Odyssey (Azamox 35% + Imazethaeyra 35% WG)	40 gm/10lit of water
3	18/08/2023	Emactine Benzoate (Benzoate 5%)	85 gm / acre
4	01/09/2023	Tata Bahar (MI Amino Acid)	250ml / acre

Table 4: Crop Protection Measures in *Kharif* Greengram

Sr. No	Date of Application	Insecticide/Fungicide/Pesticide	Quantity
1	08/07/2023	Strongarm (Diclosulam 84% WDG)	12.4gm / acre
2	21/07/2023	Emactine Benzoate (Benzoate 5%)	85 gm / acre
3	08/08/2023	Stroker, Tata Surplus	30ml /15 lit of water
4	18/08/2023	Emactine Benzoate (Benzoate 5%)	85 gm / acre

3. Crop Growth Studies of *Kharif* Soybean and Greengram

The data in respect of growth parameters during crop growth period of *Kharif* Soybean and Greengram were recorded and presented below at appropriate headings. Crop growth parameters viz., plant height, number of branches, leaves, flowers and pods development were recorded at 30, 60, and 90 days after sowing and at harvest time. Randomly 10 plants in lysimeter 1 and lysimeter 3 were selected for *Kharif* Soybean to monitor their crop growth parameters. Similarly, for Greengram, 10 plants in lysimeter 2 were selected as observation plants. The data in respect of growth parameters for *Kharif* Soybean and Greengram are presented in Table 4 and 5 respectively.

Table 5: Plant growth parameters of *Kharif* Soybean

Parameters	Lysimeter No.	30 DAS	60 DAS	90 DAS	At harvest
Height (Cm)	L1	10.2	42.2	58.6	66.4
	L3	9.8	41.1	60.2	63.7
Branches (No)	L1	5.3	10.8	29.3	26.3
	L3	6.1	11.4	28.3	29.4
Leaves (No)	L1	8.3	36.1	38.6	0
	L3	7.4	34.3	39.7	0
Flowers (No)	L1	0	12.7	5.9	0
	L3	0	13.4	6.3	0
Pods (No)	L1	0	0	13.2	20.4
	L3	0	0	12.3	16.7
Avg. Yield (q/ha)	L1	29.35			
	L3	26.94			

Table 6: Plant growth parameters of *Kharif* Greengram

Average parameters	Lysimeter No	30 DAS	60 DAS	At harvest
Height (Cm)	L2	15.1	44.9	51.4
Branches (No)	L2	4.2	12.5	14.3
Leaves(No)	L2	11.8	31.4	35.7
Flowers (No)	L2	6.0	2.3	0
Pods (No)	L2	-	14	27.2
Avg. Yield (q/ha)	L2	6.09		

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

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

$$K_c = \frac{ET_c}{ET_r} \quad \dots\dots (1)$$

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 lysimeter 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. The Penman Monteith method was used to estimate the reference crop evapotranspiration.

4.1 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, surface resistance of 70 sm⁻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.

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

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_a = 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.

5. 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.

5.1 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 7. The mean actual evapotranspiration of *Kharif* Soybean was recorded between 3.88 to 5.55 mm. From the Table 7, 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.

5.2 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 7. Data presented in Table 7 show that ETo ranges from 3.19 to 9.46 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. The computed Kc values for *Kharif* Soybean during initial, development, mid and end stages were 0.45, 0.78, 1.20 and 0.95 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 in Table 7 represents weekly lysimetric crop coefficient values for *Kharif Soybean*.

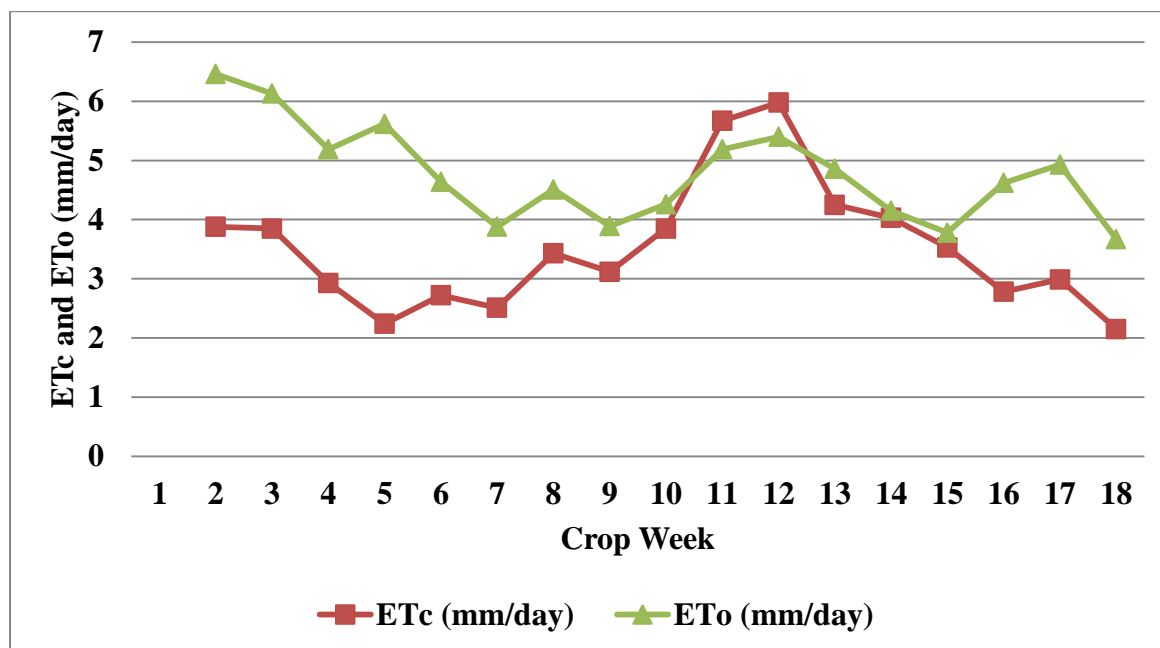


Fig. 1 : Comparative performance of week-wise recorded ETc(mm/day) and ET0 (mm/day) during experimentation for *Kharif Soybean*

Table 7: 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	3.88	6.46	0.60	0.61	0.61	Initial (20 Days)	0.60
2	3.85	6.13	0.63	0.67	0.65		
3	2.93	5.19	0.56	0.54	0.55		
4	2.24	5.62	0.40	0.45	0.43	Development (35 days)	0.63
5	2.72	4.64	0.59	0.56	0.58		
6	2.51	3.88	0.65	0.62	0.64		
7	3.43	4.51	0.76	0.78	0.77		
8	3.12	3.89	0.80	0.67	0.74	Mid (45 days)	1.0
9	3.85	4.26	0.90	0.98	0.94		
10	5.67	5.19	1.09	1.03	1.06		

11	5.98	5.4	1.11	1.15	1.13		
12	4.25	4.86	0.87	0.96	0.92		
13	4.03	4.15	0.97	1.03	1.00		
14	3.53	3.78	0.93	0.92	0.93		
15	2.78	4.62	0.60	0.71	0.66	End (15 days)	0.65
16	2.99	4.93	0.61	0.74	0.68		
17	2.15	3.67	0.59	0.65	0.62		

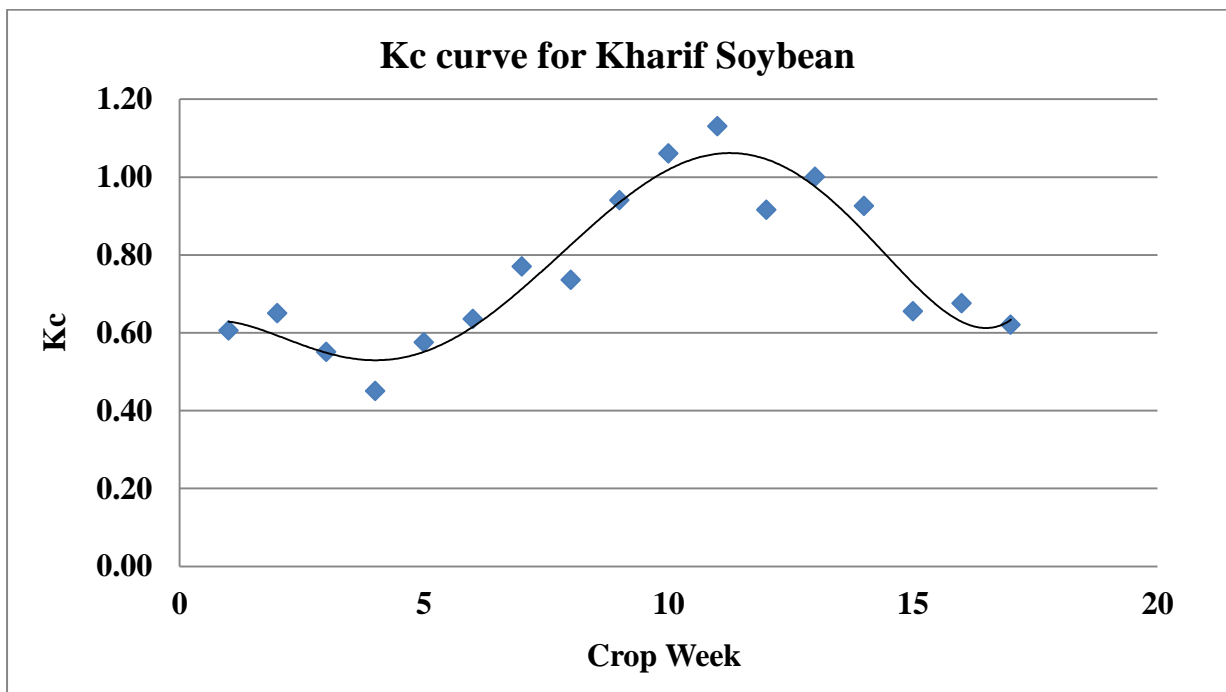


Fig. 2: Weekly lysimetric Kc curve of *Kharif* Soybean during crop growth period

6. 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).

6.1 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 8. The mean actual evapotranspiration of *Kharif* Greengram was recorded between 3.51 to 4.06 mm/day. From the Table 8, it is found that crop water requirement was lower during initial and final stage while higher during development stage of crop growth period.

6.2 Reference evapotranspiration (ET₀)

The daily reference evapotranspiration was converted into week wise average reference evapotranspiration (Table 7). Data presented in Table 7 show that ET₀ ranges between 2.93 mm to 8.36 mm/day for *Kharif* Greengram. Fig. 3 represents comparative performance of week wise recorded actual evapotranspiration (ET_c) and reference evapotranspiration (ET₀) *Kharif* Greengram.

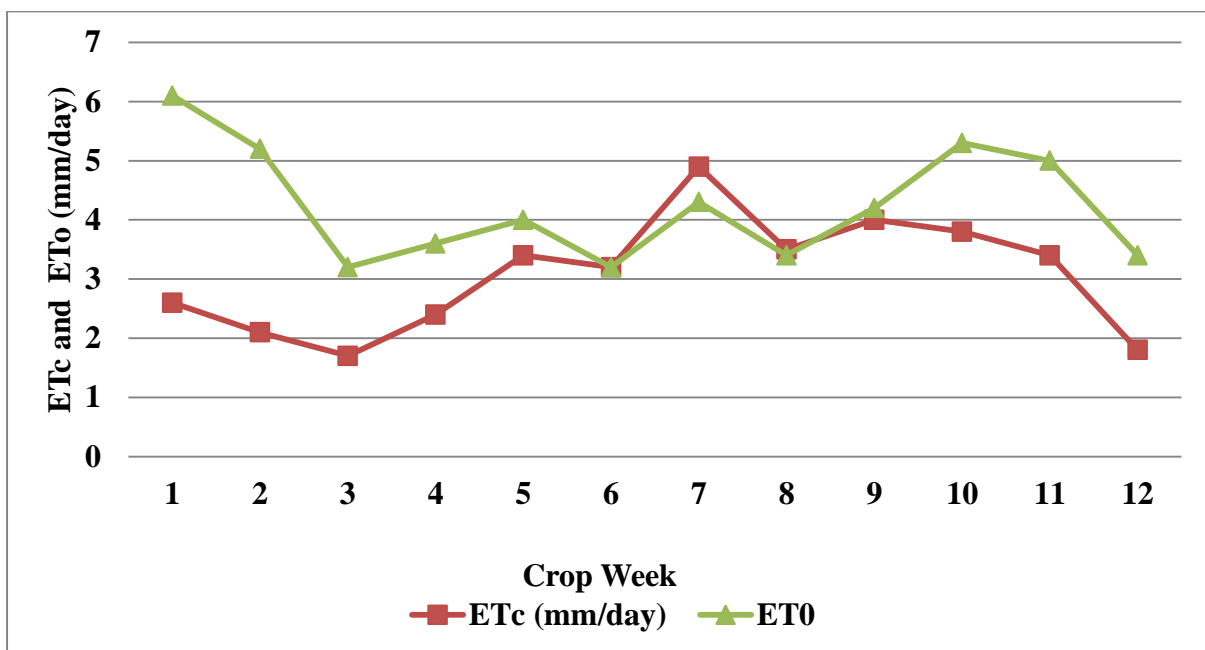


Fig. 3: Comparative performance of week-wise recorded ET_c(mm/day) and ET₀ (mm/day) during experimentation for *Kharif* Greengram

Table 8: Weekly lysimetric crop coefficient (K_c) values for *Kharif* Greengram

Crop Week	ET _c (mm/day)	ET ₀	Weekly K _c by lysimeter 3	Crop Growth stages	Stage-wise K _c values
1	4.06	7.00	0.58	Initial (15 Days)	0.60
2	3.94	6.35	0.62		
3	3.76	6.06	0.62		
4	3.69	4.50	0.82	Development (25 days)	1.05

5	3.78	3.74	1.01		
6	3.67	3.19	1.15		
7	3.51	2.93	1.20		
8	3.67	3.11	1.18	Mid (25 days)	1.02
9	3.67	3.46	1.06		
10	3.65	4.40	0.83		
11	3.82	6.82	0.56	End (15 days)	0.49
12	3.51	8.36	0.42		

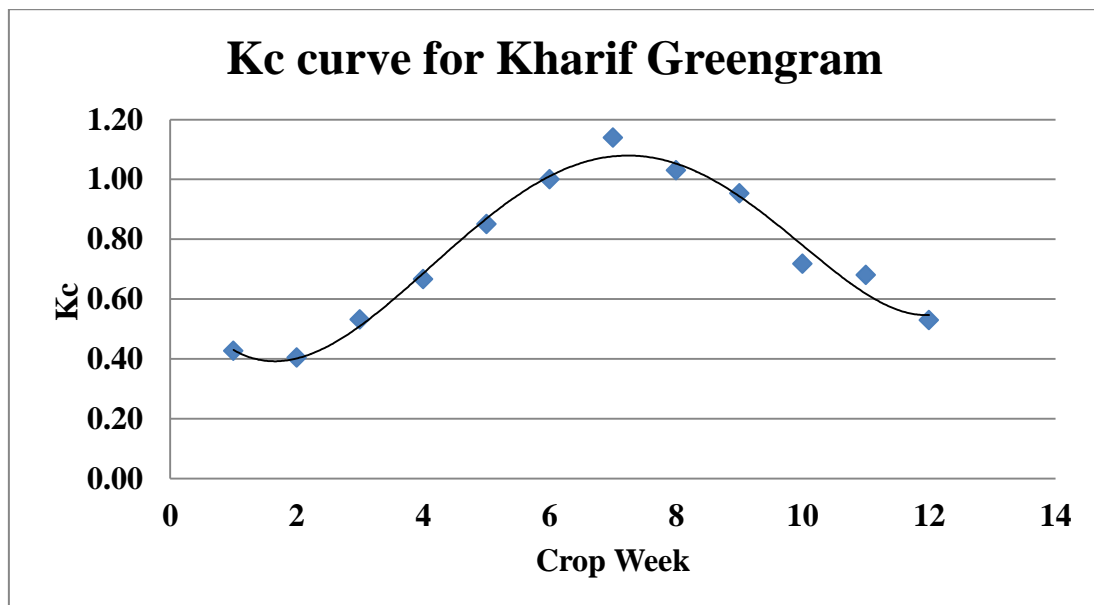


Fig. 4: Weekly lysimetric Kc curve of *Kharif* Greengram during crop growth period

7. Yield data of *Kharif* Soybean

Table 9: Yield of *Kharif* Soybean in Lysimeter 1 & 3 and field plots

Particular	Production (gm)	Yield per unit area (q/ha)
Lys.1	548	24.36
Lys.3	563	25.02
Field Plot	514	22.84

8. Yield data of *Kharif* Greengram

Table 10: Yield of *Kharif* Greengram in Lysimeter 2 and field plots

Particular	Production (gm)	Yield per unit area (q/ha)
Lys.2	137	6.09
Field Plot	102	4.53

9. 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 taluka wise irrigation water requirement for *Kharif* Soybean and Greengram are given in **Annexure I and II** respectively.

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