

Phase IX

Comprehensive Report *on*

Crop Kc, Water Requirement of Kharif Cotton and Pigeon pea



for

Project on;

**“Determination of Crop Coefficients for Major Crops by
Lysimetric Studies”**

at

**DEPARTMENT OF IRRIGATION AND DRAINAGE ENGINEERING,
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Phase IX
Comprehensive Report on Crop Kc, Water Requirement of
Kharif Cotton and Pigeon Pea

“Determination of crop coefficients for major crops by Lysimetric studies”

Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

Title of the Project: Determination of crop coefficients for major crops by Lysimetric studies” at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

Location: Department of Irrigation and Drainage Engineering, Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola.

Duration: Three years.

Total outlay: Rs. 38.38 lakhs.

Investigators:

Principal Investigator : Dr. M.M. Deshmukh, Associate Professor and Head, Department of Irrigation and Drainage Engineering Dr. PDKV, Akola.

Co-Principal Investigator : Dr. A.N. Mankar, Assistant Professor, Department of Irrigation and Drainage Engineering Dr. PDKV, Akola.

Coordinator for the project for three universities (MPKV, Rahuri; Dr PDKV, Akola and VNMKV, Parbhani) : Dr. S.D. Gorantiwar, PI CAAST-CSAWM and Head, Deptt. of Agril. Engg., MPKV, Rahuri.

INTRODUCTION:

As per schedule of reporting requirements, following are the details for the fulfillment “Comprehensive Report on Crop Kc, Water Requirement of Kharif Cotton and Pigeon pea”.

Kharif cotton and pigeon pea crops for the season of year 2022 and 2023 were cultivated inside and around the lysimeters to determine to crop coefficient values.

COMPREHENSIVE (Average of 2022 and 2023) CROP COEFFICIENTS (Kc) FOR KHARIF COTTON:

The weekly crop coefficient values were computed as the ratio of weekly crop evapotranspiration and weekly reference evapotranspiration. Weekly crop

evapotranspiration was obtained from lysimeters by growing crop in lysimeters. For cotton, two lysimeters were used and the crop coefficient values were measured for both lysimeters. The crop coefficient values obtained from both lysimeters were averaged to avoid errors in the measurement. The weekly crop coefficient values of cotton for Kharif season of 2022 (alternate Kc values) and 2023 were averaged to get more precise Kc values which are represented in table 1.

Table 1. Average weekly crop coefficient (Kc) values for cotton

Crop Week	t/T	Weekly Kc Values			Stagewise Days	Stagewise Kc Values		
		Kc - 2022	Kc - 2023	Average Kc		2022	2023	Average
1	0.00	0.47	0.56	0.52	22 days - Initial Stage	0.51	0.6	0.55
2	0.04	0.50	0.59	0.55				
3	0.09	0.55	0.64	0.60				
4	0.13	0.61	0.71	0.66	38 days- Development stage	0.79	0.89	0.84
5	0.18	0.68	0.78	0.73				
6	0.22	0.76	0.86	0.81				
7	0.26	0.84	0.94	0.89				
8	0.31	0.92	1.01	0.97	59 days- Mid season stage	1.08	1.18	1.13
9	0.35	0.98	1.07	1.03				
10	0.39	1.04	1.13	1.09				
11	0.44	1.08	1.17	1.13				
12	0.48	1.11	1.2	1.16				
13	0.53	1.12	1.22	1.17				
14	0.57	1.12	1.22	1.17				
15	0.61	1.10	1.21	1.16				
16	0.66	1.07	1.18	1.13	48 days - Late stage	0.85	0.87	0.86
17	0.70	1.06	1.14	1.10				
18	0.74	1.02	1.08	1.05				
19	0.79	0.97	1.02	1.00				
20	0.83	0.90	0.94	0.92				
21	0.88	0.84	0.86	0.85				
22	0.92	0.72	0.78	0.75				
23	0.96	0.68	0.71	0.70				
24	1.00	0.68	0.63	0.66				

The comprehensive average weekly Kc values for cotton for the growing period of 24 weeks were found 0.52, 0.55, 0.60, 0.66, 0.73, 0.81, 0.89, 0.97, 1.03, 1.09, 1.13, 1.16, 1.17, 1.17, 1.16, 1.13, 1.10, 1.05, 1.00, 0.92, 0.85, 0.75, 0.70 and 0.66 respectively. Whereas, comprehensive average stage wise Kc values for initial (22 Days), development (38 Days), mid-season (59 Days) and late season stage (48 Days) were 0.55, 0.84, 1.13 and

0.86 respectively. The highest values of crop coefficients were found during the mid-season stage which may be due to the higher canopy during mid stage. Figure 1 shows the comparison between weekly crop coefficient values obtained for cotton during season 2022 and 2023.

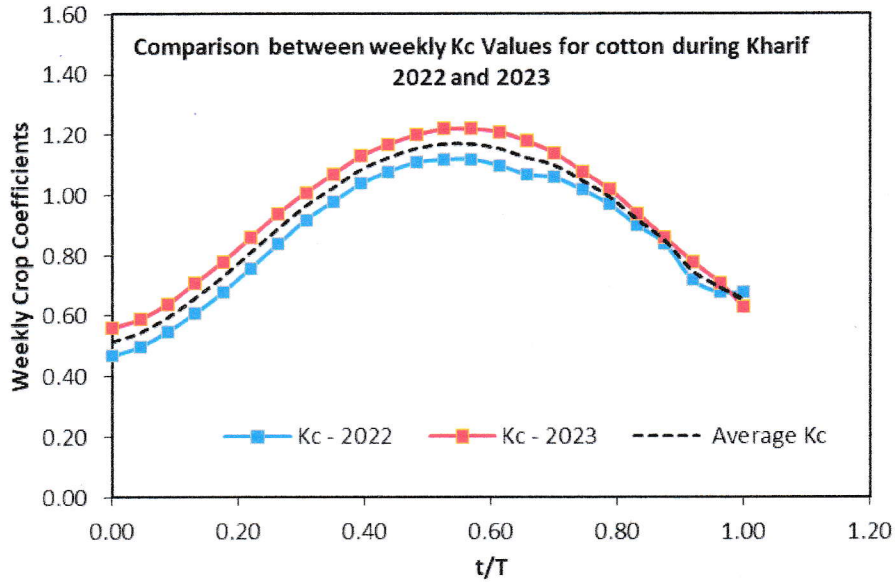


Figure 1. Comparison between weekly Kc values for cotton during Kharif season of 2022 and 2023

Equation No. 1 given below is polynomial equation obtained for comprehensive average weekly K_c values for cotton against 't/T' to derive daily K_c values.

$$K_{c_t} = 5.7075 \left(\frac{t}{T}\right)^4 - 12.522 \left(\frac{t}{T}\right)^3 + 6.4562 \left(\frac{t}{T}\right)^2 - 0.4923 \left(\frac{t}{T}\right) + 0.5125 \dots\dots\dots (1)$$

COMPREHENSIVE (Average of 2022 and 2023) CROP COEFFICIENTS (K_c) FOR PIGEON PEA:

The weekly crop coefficient values were computed as the ratio of weekly crop evapotranspiration and weekly reference evapotranspiration. For pigeon pea, two lysimeters were used and the crop coefficient values were measured for both lysimeters. The weekly crop coefficient values of pigeon pea for kharif season of 2022 (alternate K_c values) and 2023 were averaged to get more precise K_c values which are represented in table 2.

Table 2. Average weekly crop coefficient (Kc) values for pigeon pea

Crop Week	t/T	Weekly Kc Values			Stagewise Days	Stagewise Kc Values		
		Kc - 2022	Kc - 2023	Average Kc		2022	2023	Average
1	0.04	0.48	0.53	0.51	24 -Initial Stage	0.50	0.55	0.53
2	0.08	0.49	0.54	0.52				
3	0.12	0.51	0.57	0.54				
4	0.16	0.56	0.61	0.59	52 days - development stage	0.78	0.84	0.81
5	0.19	0.61	0.67	0.64				
6	0.23	0.67	0.73	0.70				
7	0.27	0.74	0.80	0.77				
8	0.31	0.81	0.87	0.84				
9	0.35	0.88	0.93	0.91				
10	0.39	0.94	1.00	0.97				
11	0.43	0.99	1.05	1.02	60 days - Mid season stage	1.08	1.12	1.10
12	0.47	1.04	1.09	1.07				
13	0.51	1.07	1.13	1.10				
14	0.54	1.10	1.15	1.13				
15	0.58	1.11	1.16	1.14				
16	0.62	1.11	1.16	1.14				
17	0.66	1.10	1.15	1.13				
18	0.70	1.07	1.12	1.10				
19	0.74	1.03	1.08	1.06	46 days - Late Season stage	0.76	0.81	0.79
20	0.78	0.98	1.03	1.01				
21	0.82	0.91	0.97	0.94				
22	0.86	0.84	0.90	0.87				
23	0.89	0.76	0.83	0.80				
24	0.93	0.66	0.76	0.71				
25	0.97	0.57	0.68	0.63				
26	1.00	0.51	0.61	0.56				

The comprehensive average weekly Kc values for pigeon pea for the growing period of 26 weeks were found 0.51, 0.52, 0.54, 0.59, 0.64, 0.70, 0.77, 0.84, 0.91, 0.97, 1.02, 1.07, 1.10, 1.13, 1.14, 1.14, 1.13, 1.10, 1.06, 1.01, 0.94, 0.87, 0.80, 0.71, 0.63 and 0.56 respectively. Whereas, comprehensive average stage wise Kc values for initial (24 Days), development (52 Days), mid-season (60 Days) and late season stage (46 Days) were 0.53, 0.81, 1.10 and 0.79 respectively. The highest values of crop coefficients were found during the mid-season stage which may be due to the higher canopy during mid stage. Figure 2 shows the comparison between weekly crop coefficient values obtained for pigeon pea for season 2022 and 2023.

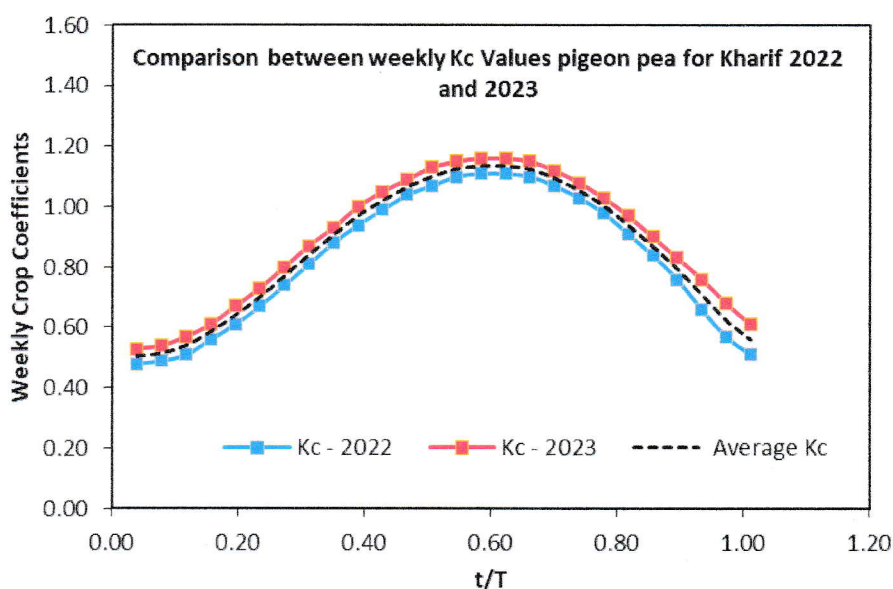


Figure 2. Comparison between weekly Kc values for pigeon pea for kharif season of 2022 and 2023

Equation No. 2 given below is polynomial equation obtained for comprehensive average weekly K_c values for pigeon pea against 't/T' to derive daily K_c values.

$$Kc_t = 6.4884 \left(\frac{t}{T}\right)^4 - 16.012 \left(\frac{t}{T}\right)^3 + 10.476 \left(\frac{t}{T}\right)^2 - 0.9041 \left(\frac{t}{T}\right) + 0.5273 \dots\dots (2)$$

Comparison between Lysimetric and FAO Modified Kc values for cotton:

Average lysimetric Kc values for the year 2022 and 2023 were found as 0.55, 0.84, 1.13 and 0.86 for initial, development, midseason and late season stages of cotton respectively. Whereas the FAO modified Kc values are 0.51, 0.79, 1.08 and 0.85 for initial, development, mid-season and late season stage. Table 3 shows the comparison between comprehensive average lysimetric kc values and FAO modified Kc values for cotton.

Table 3. Comparison between average lysimetric and FAO modified Kc values for cotton

Growth Stages	Average Lysimetric Kc (2022 & 2023)	FAO Kc	FAO modified Kc
Initial season stage	0.55	0.35	0.51
Development Stage	0.84	-	0.79
Mid-season stage	1.13	1.15	1.08
Late season stage	0.86	0.70	0.85

Figure 3 shows the comparison between comprehensive average weekly K_c values obtained from lysimetric and FAO modified K_c values for cotton.

The polynomial equation (3) obtained for FAO modified K_c values for cotton is as follow;

$$K_{c_t} = 7.5945 \left(\frac{t}{T}\right)^4 - 16.439 \left(\frac{t}{T}\right)^3 + 9.2161 \left(\frac{t}{T}\right)^2 - 0.1751 \left(\frac{t}{T}\right) + 0.4698 \dots\dots\dots(3)$$

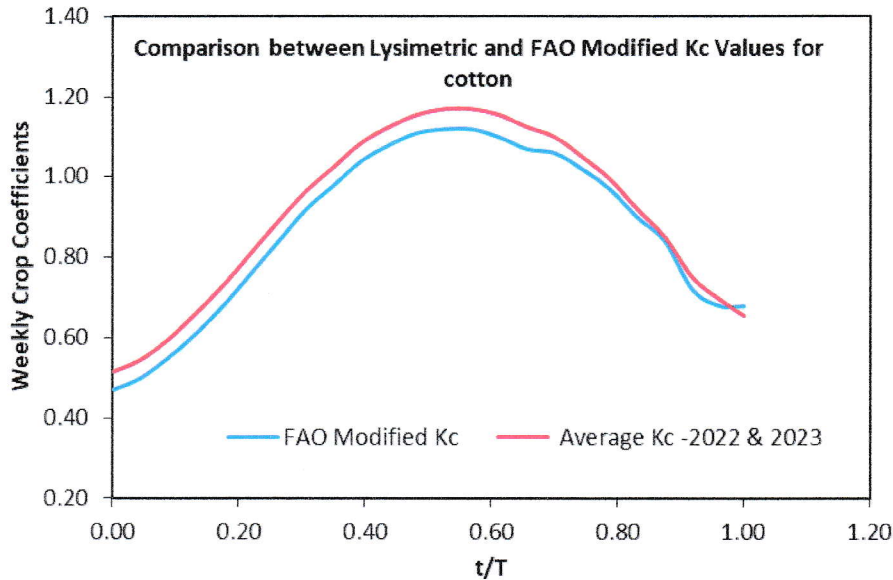


Figure 3. Comparison between average lysimetric (2022 and 2023) and FAO modified K_c values for cotton

Comparison between Lysimetric and FAO Modified K_c values for Pigeon pea:

Average Lysimetric K_c values for the year 2022 and 2023 were found as 0.53, 0.81, 1.10 and 0.79 for initial, development, midseason and late season stages of pigeon pea respectively. Whereas the FAO modified K_c values are 0.50, 0.78, 1.08 and 0.76 for initial, development, mid-season and late season stage. Table 4 shows the comparison between comprehensive average lysimetric k_c values and FAO modified K_c values for pigeon pea.

Table 4. Comparison between lysimetric and FAO modified K_c values for pigeon pea

Growth Stages	Average Lysimetric K _c (2022 &2023)	FAO K _c	FAO modified K _c
Initial season stage	0.53	0.40	0.50
Development stage	0.81	-	0.78
Midseason stage	1.10	1.15	1.08
Late season stage	0.79	0.55	0.76

Figure 4 shows the comparison between polynomial curves obtained from lysimetric and FAO modified K_c values for pigeon pea.

The polynomial equation (4) obtained for FAO modified K_c values for pigeon pea is as follow;

$$K_{c_t} = 6.3079 \left(\frac{t}{T}\right)^4 - 15.341 \left(\frac{t}{T}\right)^3 + 9.6189 \left(\frac{t}{T}\right)^2 - 0.5745 \left(\frac{t}{T}\right) + 0.4895 \dots\dots (4)$$

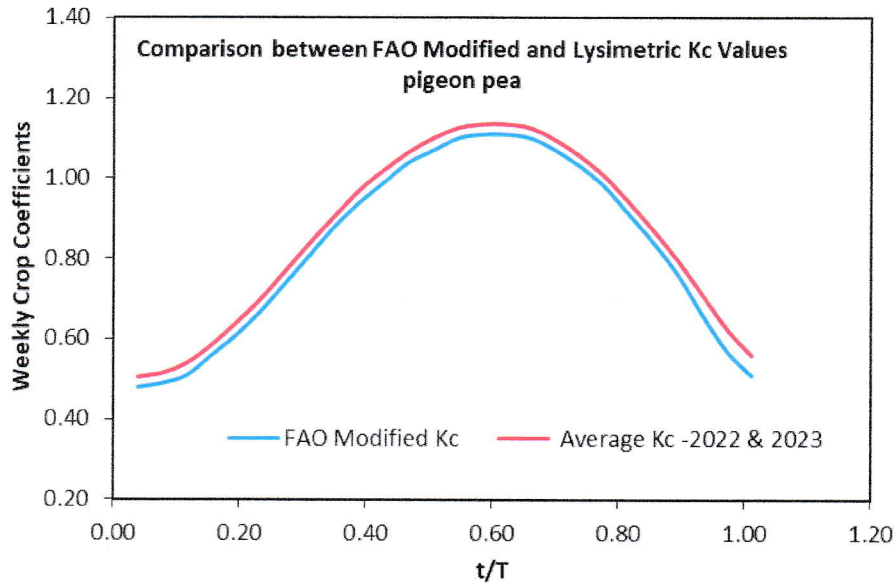




Figure 4. Comparison between lysimetric and FAO modified K_c values for pigeon pea

WATER REQUIREMENT FOR COTTON AND PIGEON PEA

Taluka wise weekly crop water requirement was determined using comprehensive average lysimetric K_c values obtained for cotton and pigeon pea by ignoring the effective rainfall for tehsils in Vidarbha region. Also, the irrigation water requirement was determined by considering the crop water requirement at different irrigation efficiencies. It was calculated for surface irrigation at 40%, 50% and 60% irrigation efficiency, for drip irrigation at 90% and 95% irrigation efficiency and for sprinkler irrigation at 80% and 85% irrigation efficiency. The taluka wise water requirement for cotton and pigeon pea is given in annexure for above mentioned irrigation efficiencies.


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