Inception Report of
"Determination of crop coefficients for major crops by Lysimetric studies" at Mahatma Phule Krishi Vidyapeeth, Rahuri

---

Title of the project: Determination of crop coefficients for major crops by Lysimetric studies" at Mahatma Phule Krishi Vidyapeeth, Rahuri

Location: CAAST-CSAWM field, Mahatma Phule Krishi Vidyapeeth, Rahuri

Duration; Three years

Total outlay: Rs. 47.43 lakhs

Investigators:

Principal Investigator	:	Dr. A.A. Atre, CAAST-CSAWM Member and Professor of SWCE, Dr. ASCAET, Rahuri
Co-Principal Investigator	:	Dr. M.G. Shinde, Co-PI CAAST-CSAWM and Professor of SWCE, MPKV, Rahuri
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

Activities completed

A. Signing of MoU

The Memorandum of Understanding between Nanaji Deshmukh Krishi Sanjeevani Prakalp (NDKSP), Government of Maharashtra earlier referred as Project on Climate Resilient Agriculture (PoCRA) and Mahatma Phule Krishi Vidyapeeth, Rahuri was signed on January 17, 2020 at Mumbai by Project Director, PoCRA and the Director of Research, MPKV, Rahuri in presence of ADG (NRM), ICAR, New Delhi; Director, ICAR-CRIDA, Hyderabad; NDKSP Authorities and PI of the project from MPKV, Rahuri and VNMKV, Parbhani.

B. The First Meeting of Co-ordination Committee

The first meeting of Coordination Committee for the project entitled "Determination of Crop Coefficient for Major Crops by Lysimetric Studies" sanctioned by Nanaji Deshmukh Krushi Sanjeevani Prakalp (NKDSP), Government of Maharashtra to MPKV, Rahuri; Dr.PDKV, Akola and VNMKV, Parabhani was held on February 7, 2020 at 0930 hrs in the Alumni Cell Meeting Hall, Dr.A.S.College of Agril. Engg. & Technology, MPKV, Rahuri.

The following members attended the meeting.

1. Shri. Vijay Kolekar, Chief Agronomist, PoCRA, Government of Maharashtra, Mumbai.
2. Mr. Rafique Naikwadi, PoCRA, Government of Maharashtra, Mumbai
3. Dr. S.D. Gorantiwar, Coordinator, Lysimetric Project & PI, CAAST-CSAWM & Head, Deptt. of Agril.Engg., MPKV, Rahuri
4. Dr. U.M. Khodke, Principal Investigator, Lysimetric Project & Associate Dean, College of Agril. Engg. & Technology, VNMKV, Parbhani
5. Dr. A.A. Atre, Principal Investigator, Lysimetric Project; Procurement Officer, CAAST-CSAWM and Professor of SWCE, MPKV, Rahuri
6. Dr. S.B. Wadtkar, Principal Investigator, Lysimetric Project & Head, Deptt. of IDE, Dr. PDKV, Akola
7. Dr. M.G. Shinde, Co-Principal Investigator, Lysimetric Project; Co-PI, CAAST-CSAWM and Professor of SWCE, MPKV, Rahuri
8. Dr. M.M. Deshmukh, Co-Principal Investigator, Lysimetric Project & Associate Professor of IDE, Dr.PDKV, Akola
9. Dr. A.N. Mankar , Co-Principal Investigator, Lysimetric Project & Associate Professor of IDE, Dr.PDKV, Akola
10. Dr. Harish Aware , Co-Principal Investigator, Lysimetric Project & Associate Professor of IDE, VNMKV, Parbhani
11. Dr. Vishal Ingale, Co-Principal Investigator, Lysimetric Project & Assistant Professor of IDE, VNMKV, Akola
12. Dr. P.G.Popale, Assistant Professor of IDE, CAAST-CSAWM, MPKV, Rahuri

Research Associates of CAAST-CSAWM were also present for the meeting.

The following points were discussed and finalized

Technical and Scientific

1. The detailed methodology for the determination of the crop coefficients by lysimeters.
2. The criteria for the selection of the site for the installation of lysimeters.
3. The estimation of the weekly taluka-wise evapotranspiration, crop water requirement and irrigation water requirement for the jurisdiction of the respective Universities (MPKV, Rahuri; Dr. PDKV, Akola and VNMKV, Parbhani). The MPKV, Rahuri has already estimated the weekly taluka-wise evapotranspiration, crop water requirement and irrigation water requirement for major crops using the reference crop evapotranspiration estimated by Penman Monteith or Hargreaves Samani method and crop coefficients developed by the MPKV through RKVY Project on Irrigation Water Requirement Advisory Service (IWRAS) or FAO crop coefficients for the crops for which the crop coefficients were not developed by the MPKV, Rahuri. The weekly taluka-wise evapotranspiration, crop water requirement and irrigation water requirement for major crops in the jurisdiction of MPKV, Rahuri are available for the use on website of RKVY-IWRAS.

4. It was decided that Dr. PDKV, Akola and VNMKV, Parbhani also estimate the weekly taluka-wise evapotranspiration, crop water requirement and irrigation water requirement by using the crop coefficients developed by the MPKV through RKVY-IWRAS or FAO crop coefficients for the crops for which the crop coefficients were not developed by the MPKV, Rahuri and later update the values once the crop coefficient values are available locally from this project.
5. The members of the committee visited the lysimeter complex installed at RKVY-IWRAS farm; and discussed about various components of lysimeters, data transfer.
6. The committee also visited the CAAST-CSAWM farm and inspected the site where currently the lysimeters for the nutrient balance are being installed.

Administrative and Managerial

1. It was decided that total ten reports should be submitted under the signature of Principal Investigator and Co-Principal Investigators. The invoice for release of funds needs to be sent under the signatures of PI, Co-PI and Comptroller, MPKV, Rahuri so that the funds could be disbursed by PoCRA for carrying out the activities as stated in the proposal. In the entire duration of 36 months of the project, ten reports should be submitted according to the time schedule, expected contents in the reports, and deliverables as outlined in the finalised project proposal.
2. The MPKV, Rahuri to facilitate for the computational facilities if required to Dr. PDKV, Akola and VNMKV, Parbhani for the purpose of estimation of reference crop evapotranspiration, crop water and requirement and irrigation water requirement; and corresponding mapping.

C. Methodology

The methodology that has been finalized for the determination of the crop coefficients based on the previous experience is provided in Appendix-A.

D. Time Schedule

The time schedule including the procurement and installation of the lysimeters; experimentation, data analysis etc. is provided in Appendix-B.

E. Selection of the site

The exact site for the installation of the lysimeters has been selected on CAAST-CSAWM farm; and the analysis of the soil samples for their physical properties such as bulk density, infiltration characteristics, in-situ hydraulic conductivity, field capacity and wilting point; and chemical properties such as EC, pH has been initiated.

Co- Principal Investigator

Principal Investigator

Project on Determination of Crop coefficients by Lysimetric Studies
Mahatma Phule Krishi Vidyapeeth, Rahuri 413722

Appendix-A

Methodology

The major component of the crop water requirement is the crop evapotranspiration. The estimation of crop evapotranspiration is, therefore, necessary for appropriate management of irrigation water for irrigation, water budgeting and matching demand and supply. The water requirement comprised mainly of evapotranspiration varies as per crop, its growth stage and prevailing weather conditions. Thus crop evapotranspiration is the function of crop characteristics and weather characteristics. Reference crop evapotranspiration, which is the evapotranspiration of reference crop, that is fully grown and never short of water takes care of the weather characteristics. The crop evapotranspiration is then related to reference crop evapotranspiration through a factor called crop coefficient which varies over the growth period of crop. Thus the reference crop evapotranspiration and crop coefficient values are essential for estimating the crop water requirement.

Importance of considering locally developed Kc values

Currently most of the studies consider the crop coefficient values documented by FAO based on the average values all over the world. Therefore, consideration of the global averages of crop coefficient does not result in appropriate estimation of crop evapotranspiration and hence leads to inappropriate application of water, resulting in under or over irrigation and finally either in decreased productivity and/ or increased wastage of scarce water resources. FAO also cautioned to use the values documented by them carefully, as those values are average of values over different regions of the world. As the evapotranspiration values are influenced by local climatic conditions, crop evapotranspiration values need to be measured locally and hence crop coefficient values need to be estimated locally. Thus for the estimation of accurate crop water requirement, it is necessary to determine the crop coefficient values locally over the crop growth season for different crops of the regions.

The deviation of the crop coefficient values documented by FAO and determined locally with the help lysimetric and field water balance studies at Rahuri (Maharashtra) for wheat and sugarcane showed considerable variations. In case of wheat, the locally developed Kc values were more than those documented by FAO over the entire crop growth season; and in case of sugarcane, locally developed values were less during early and late seasons and more during mid-season compared to the FAO documented values. These facts bring out the most important conclusion that, though there is considerable variation in Kc values but there is no specific trend of variation between locally developed and FAO documented values.

The absolute variation in water requirement for the typical region of Rahuri between FAO documented and locally developed values for wheat was 17.7 and 18.52 cm, respectively for wheat and sugarcane. This translates in to 8 to 12% variation in the crop yield as estimated from crop yield estimation model “SWAB-CRYB”. These figures show the importance of the locally developed Kc values. Moreover, locally developed Kc values provide the accurate values and thus the confidence amongst the users for estimating water requirement based on Kc values.

Objectives

The study is proposed at three different universities to determine the crop coefficients for the major crops grown in villages selected by PoCRA in Eastern, Central and Northern parts of Maharashtra by lysimetric studies. Mahatma Phule Krishi Vidyapeeth, Rahuri will be carrying out the study to estimate the values of crop coefficients of important field crops, viz. fodder Bajara, Sesame, and Gram over their growth period by using lysimetric study.

Methodology

The detail methodology for measurement of Kc values is described below.

Crop coefficient (Kc) is the ratio of crop evapotranspiration (ETc) when grown under no stress condition to reference crop evapotranspiration (ETr) as given by following equation

$$Kc = \frac{ETc}{ETr}$$

The reference crop evapotranspiration is estimated by the Penman Monteith method with the help of locally measured or recorded weather parameters, while the actual evapotranspiration needs to be determined by soil root zone water balance by lysimetric method.

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

Penman Monteith Method

The analysis of the performance of the various calculation methods revealed the need for formulating a standard method for the computation of ETr. The FAO Penman-Monteith method has been recommended as the sole standard method. It is a method with strong likelihood of correctly predicting ETr 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, the FAO Penman-Monteith method was developed as presented by following equation.

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

where,

ET_O - potential evapotranspiration (mm day^{-1}),

R_n - 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),

u_2 - 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 Vidyapeeth, Rahuri under the RKVY Project on Irrigation Water Requirement Service will be used for the estimation of the reference crop evapotranspiration by the Penman Monteith Method.

The Kc values will be represented as daily values, crop growth stage wise values and the polynomial equation form for use in computer models and DSS. The polynomial equations with (t/T) as independent variable upto 5^{th} order will be tried for fiting with Kc values.

$$Kc_t = \sum a_i \left(\frac{t}{T}\right)^i \quad for\,'i'\,ranging\,from\ 0\,to\,5$$

where,

Kc_t - crop coefficient of t^{th} day.

a_i - constants of equations.

t - day considered.

T - total period of crop growth from sowing to harvesting (days).

Crop Water Requirement

The water requirement of the crops for which the crop coefficient values are proposed to be developed will be determined based on the meteorological data of previous 30+ years, obtained from the different meteorological stations over the State of Maharashtra. The GIS maps will be developed for knowing the water requirement values at the desired location. These values will be helpful for planning the deficit, supplemental and protective irrigation strategies when there are long dry spells and water scarcity that are recurrent situations in most part of the Western, Central and Eastern Maharashtra. The developed values of water requirement will also be helpful in water budgeting studies.

Locations and Crops

It is proposed to conduct the experimentations for determining the crop coefficient values in the jurisdiction of Mahatma Phule Krishi Vidyapeeth, Rahuri at Centre for Advanced Agricultural Science and Technology (CAAST) on Climate Smart Agriculture and Water Management (CSAWM), MPKV, Rahuri.

Timeline for completion of assignment

Timeline for completion of assignment is given in Appendix-B.

Deliverables

In the entire duration of 36 months of the project, ten reports will be submitted according to the time schedule depicted in Appendix-B. The expected contents in the reports would be as under.

Report	Deliverables	Expected time of submission	Remarks
I	Inception Report. This will contain methodology for determining the Kc, time schedule of different reports. Invoice for release of first 10% i.e. Rs. 4.743 lakh under signature of Comptroller, MPKV, Rahuri.	3rd week of February 2020	First report
II	Report containing the actions taken for installation and setting up of lysimeters. Expenditure statement for the financial year 2019-2020. Invoice for release of second 10% grants i.e. Rs. 4.743 lakh under signature of Comptroller, MPKV, Rahuri.	3rd week of June 2020	
III	Report on crop Kc, water and irrigation requirement by different irrigation practices for Kharif Sesame, Rabi Gram and summer Fodder Bajra based on normalized Kc based on FAO calculations and technical support. Invoice for release of third 10% i.e. Rs. 4.743 lakh under signature of Comptroller, MPKV, Rahuri.	1st week of August 2020	
IV	Status report on crop Kc, water requirement of Kharif Sesame with different irrigation practices and technical support. Invoice for release of fourth 10% i.e. Rs. 4.743 lakh under signature of Comptroller, MPKV, Rahuri.	1st week of January 2021	
V	Status report on crop Kc, water requirement of Rabi Gram along with suitable shading factors with different irrigation practices and technical support. Expenditure statement for the financial year 2020-2021. Invoice for release of fifth 10% i.e. Rs. 4.743 lakh under signature of Comptroller, MPKV, Rahuri.	1st week of May 2021	
VI	Status report on crop Kc, water requirement of Summer Fodder Bajra along with suitable shading factors with different irrigation practices and technical support. Invoice for release of sixth 10% i.e. Rs. 4.743 lakh under signature	1st week of September 2021	

	of Comptroller, MPKV, Rahuri.		
VII	Comprehensive report of Kc for Kharif Sesame, Rabi Gram and Summer Fodder Bajra. Status report on second year crop Kc, water requirement of Kharif Sesame along with suitable shading factors with different irrigation practices and technical support. Invoice for release of seventh 10% i.e. Rs. 4.743 lakh under signature of Comptroller, MPKV, Rahuri.	1st week of January 2022	
VIII	Status report on second year crop Kc, water requirement of Rabi Gram along with suitable shading factors with different irrigation practices and technical support. Expenditure statement for the financial year 2021-2022. Invoice for release of eighth 10% i.e. Rs. 4.743 lakh under signature of Comptroller, MPKV, Rahuri.	1st week of May 2022	
IX	Status report on second year crop Kc, water requirement of Fodder Bajra along with suitable shading factors with different irrigation practices and technical support. Comprehensive report of Kc for two years for Kharif Sesame, Rabi Gram and Summer Fodder Bajra. Invoice for release of **ninth and tenth** 10% i.e. Rs. 9.486 lakh under signature of Comptroller, MPKV, Rahuri.	2nd week of August 2022	
X	Final Report along with financial statement and technical support.	2nd week of February 2023	

Appendix-B

Timeline and Activity Chart

Activity	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Year	2020												2021												2022												2023	
Setup of Lysimeter Lab																																					
Procurement of Lysimeter																																					
Installation of Lysimeter																																					
Lysimeter Experiments																																					
Experiments					Sesame				Gram				Fodder Bajara				Sesame				Gram				Fodder Bajara				Sesame				Gram				
Analysis, Kc and Water Requirement																																					
Analysis								Sesame 1 Y				Gram 1 Y				Fodder Bajara 1Y				Sesame 2 Y				Gram 2 Y				Fodder Bajara 2Y				Sesame 3 Y				Gram 3 Y	
Submission of Reports																																					
Report	1				2		3					4				5				6				7				8			9						10

Appendix-B

Timeline and Activity Chart

Activity	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Year	2021												2022												2023											
Setup of Lysimeter Lab																																				
Procurement of Lysimeter																																				
Installation of Lysimeter																																				
Lysimeter Experiments																																				
Experiments						Sesame				Gram			Fodder Bajara				Sesame					Gram			Fodder Bajara				Sesame							
Analysis, Kc and Water Requirement																																				
Analysis									Sesame 1 Y				Gram 1 Y				Fodder Bajara 1Y				Sesame 2 Y				Gram 2 Y				Fodder Bajara 2Y				Sesame 3 Y			
Submission of Reports																																				
Report	1				2			3				4				5				6				7				8				9				10