Preamble:

The land and water are vital inputs for the successful agriculture and it is now need of the time that these resources along with other resources are used to their maximum efficiency. This university has kept these issues high on its agenda due to typical land and water resources scenario in its jurisdiction. The current irrigation potential of the state is about 16% and this may increase to 30% if all the water resources are harnessed to full extent and the irrigation technologies are used to their current status. However the development of new water resources is becoming increasingly difficult due to economic reasons and environmental concerns. Hence, the viable option is to promote and use the water saving irrigation technologies such as micro-irrigation methods and precision and protective cultivation to the fullest precision. This university initiated the systematic research studies on all aspects of micro-irrigation methods including irrigation scheduling, fertigation, design and evaluation since 1985 and today has generated the wealth of knowledge on microirrigation. The visible effects of these efforts can be seen from the installation of microirrigation and sprinkler irrigation systems over 12.00 lakh hectares in 10 districts of its jurisdiction. This is the highest concentration of adoption of this system in India. In additions to this the University developed the protected cultivation technologies (polyhouse and shadnet house) along with the irrigation and fertigation management, IT applications in irrigation water management, drainage technologies and basic knowledge such as crop coefficient, yield response factors, spectral library and response; and NDVI values for different crops.

This department is associated with teaching for UG, PG and Ph.D. programmes through experienced and highly qualified staff members working on its regular establishment. The fundamentals associated with land and water engineering are taught in the UG programme leading to B.Tech. degree in Agricultural Engineering. The students are well exposed to theoretical and practical aspects through the lectures and practicals with advanced state of art teaching aids. The need based applied type of research programmes are carried out through B.Tech, M.Tech and Ph.D students project; ad-hoc and RKVY Schemes. Since the inception of the department, the research studies have been conducted out in the areas viz. irrigation scheduling, pressurized irrigation systems, groundwater utilization through wells and pumps,

precision farming development techniques, protected cultivation (polyhouse and shadenet house), land reclamation, web based and mobile applications. In addition to this the Department is on forefront in developing drainage and protected cultivation technologies and RS & GIS application in agriculture and smart agriculture under the climatic change scenario. This department has released about recommendations for the benefit of the stakeholders.

In the recent past the department has completed six different ad-hoc projects funded by state and national level funding agencies on micro irrigation, drainage, GIS and remote sensing, groundwater pollution, groundwater recharge and solar photovoltaic pumping system. Recent addition of internationally funded projects viz. Centre for Advanced Agricultural Science and Technology (CAAST) for Climate Smart Agriculture and Water Management (CSAWM) added new chapter to the research dimensions of the department. The staff members are keen in publication of the research finding through the reputed research journals in the country and abroad. The currently working staff members of this department has published about 19 research papers in International Journals and 167 research papers the national Journals.

The department has entered into MoU with Jain Irrigation Systems Limited, Jalgaon, Approtech Porous Pipe Irrigation system, Ahmedabad, Delft Hydraulic Institute (DHI, Netherland), New Delhi. The MoU with the national giants in the field of RS and GIS like IIRS, Deharadun, RRSC, Nagpur and MRSAC, Nagpur are under progress. These MoUs shall bring out new dimensions for collaborative research in the field of Irrigation and Drainage engineering. This department has also Precision Farming Development Centre, funded by NCPAH New Delhi which carries out the research regarding precision farming techniques in agricultural production

Academic Staff

Sr. No.	Name	Designation
1.	Dr. N. N. Firake	Associate Professor & I/C Head
2.	Dr. S. B. Gadge	Associate Professor

Academic Programmes:

A) B. Tech. (Agril. Engg.)
Capacity of students: 64
Year of start: 1969

B) M.Tech (Irrigation and Drainage Engineering)
Capacity of students: 5
Year of start: 1985

C) Ph.D (Irrigation and Drainage Engineering)

Capacity of students: 2+1*
Year of start: 2011-12
(* in service candidate)

Course Layout:

1. B. Tech. (Agril. Engg.)

Sr. No.	Course No.	Course Title	Credits
1.	IDE 231	Fluid Mechanics and Open Channel Hydraulics	(2+1)
2.	IDE 242	Irrigation Engineering	(2+1)
3.	IDE 353	Groundwater, Wells and Pumps	(2+1)
4.	IDE 354	Drainage Engineering	(2+1)
5.	IDE 365	Canal Irrigation Management	(1+1)
6.	IDE 366	Sprinkler and Micro Irrigation System	(1+1)
7.	ELE – IDE 481	Minor Irrigation and command area development	(2+1)
8.	ELE – IDE 482	Geo-informatics for land and water management	(2+1)
9.	ELE-IDE 483	Lift Irrigation System Design and Management	(2+1)
10.	ELE-IDE 484	Environmental Engineering	(2+1)
11.	ELE-IDE 485	Landscape Irrigation Design & Management	(2+1)

1. M. Tech. (Irrigation and Drainage Engineering)

Sr. No.	Subject	Mater's programme
1.	Major	20
2.	Minor	09
3.	Supporting	05
4.	Seminar	01
5.	Research	20
	Total credits	**55**
	Non credit compulsory courses	06

A) Major Subjects (Min. 20 credits)

Sr. No.	Course No.	Course Title	Credits
1.	IDE 501*	Open Channel Flow	3(3+0)
2.	IDE 502*	Design of Pressurized Irrigation Systems	2(1+1)
3.	IDE 503*	Agricultural Drainage Systems	3(2+1)
4.	IDE 504*	Ground Water Engineering	3(2+1)
5.	IDE 505	Crop Environmental Engineering	2(2+0)
6.	IDE 506	Design of Pumps for Irrigation and Drainage	2(2+0)
7.	IDE 507	Flow through Porous Media	2(2+0)
8.	IDE 508	Water Resources System Engineering	3(3+0)
9.	IDE 509	GIS and Remote Sensing for Natural Resources	3(2+1)

		Management	
10.	IDE 510	Design of Surface Irrigation System	2(1+1)
11.	IDE 511	Introductory Hydroinformatics	3(2+1)
12.	IDE 512	Aerodynamics of Evapotranspiration	3(2+1)
13.	IDE 513	Systems Management in Green House	3(2+1)
14.	IDE 514	Water Quality and Pollution Control	3(2+1)
15.	IDE 592*	Special Problem	1(0+1)
16.	IDE 595#	Industry/ Institute Training	NC

* Compulsory for Master's Programme Minimum of Three Weeks Training

B) Minor Subjects (Min. 09 credits)

Sr. No.	Course No.	Course Title	Credits
1.	MATH 501	Higher Engineering Mathematics	3(2+1)
2.	MATH 502	Methods of Numerical Analysis	2(1+1)
3.	MATH 503	Advance Calculus for Engineers	2(2+0)
4.	STAT 511	Statistical Methods for Applied Science	3(2+1)
5.	STAT 512	Experimental Design	3(2+1)
6.	SWCE 504	Watershed Management and Modeling	3(2+1)
7.	SWCE 507	Land Development and Earth Moving Machinery	2(2+0)
8.	SWCE 509	Fluvial Hydraulics	3(2+1)
9.	SWCE 510	Statistical Hydrology	3(3+0)
10.	SWCE 511	Dams and Reservoir Operations	3(2+1)

C) Supporting Subjects (Min. 05 credits)

Sr. No.	Course No.	Course Title	Credits
1.	AE 502	Similitude in Engineering	3(2+1)
2.	BSCT 501	Computer Graphics	3(2+1)
3.	MATH 504	Neural Network and Its Applications	3(2+1)
4.	FMPE 521	Computer Aided System Design	2(0+2)
5.	AE 503	Applied Instrumentation	3(2+1)
6.	BSCT 502	Computer Languages for Engineering Applications	3(1+2)

D) Seminar (01 credit)

Sr. No.	Course No.	Course Title	Credits
1.	IDE 591	Seminar	1(0+1)

E) Master's Research (20 credits)

Sr. No.	Course No.	Course Title	Credits
1.	IDE 599	Master's Research	20(0+20)

F) Non Credit Compulsory Courses

Sr. No.	Course No.	Course Title	Credits
1.	PGS 501	Library and Information Services	1(0+1)
2.	PGS 502	Technical Writing and Communications Skills	1(0+1)
3.	PGS 503 (e-Course)	Intellectual Property and its Management in Agriculture	1(1+0)
4.	PGS 504	Basic Concepts in Laboratory Techniques	1(0+1)
5.	PGS 505 (e-Course)	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)
6.	PGS 506 (e-Course)	Disaster Management	1(1+0)

2. Ph. D. (Irrigation and Drainage Engineering)

Sr. No.	Subject	Doctoral Pro gramme
1.	**Major**	**15**
2.	**Minor**	**08**
3.	**Supporting**	**05**
4.	**Seminar**	**02**
5.	**Research**	**45**
	Total credits	**75**
	Non credit compulsory courses*	**06**

*** exempted, if completed in Master's degree**

A) Major Subjects (Min. 15 credits)

Sr. No.	Course No.	Course Title	Credits
1.	IDE 601*	Advanced Hydromechanics in Soil Aquifer Systems	3(3+0)
2.	IDE 602 *	Advances in Irrigation and Drainage	2(2+0)
3.	IDE 603	Hydro-Chemical Modelling and Pollutant Management	3(3+0)
4.	IDE 604	Plant Growth Modelling and Simulation	3(3+0)
5.	IDE 605	Pipe Network Analysis	3(2+1)
6.	IDE 606	River Basin Models	3(1+2)
7.	IDE 607	Ground Water Geology and Geophysics	3(2+1)
8.	IDE 608	Soft Computing in Water Resources	3(2+1)
9.	IDE 609	Advances in GIS and Remote Sensing for Land and Water Resources Management	3(2+1)
10.	IDE 610	Risk Management in Water resources	3(2+1)
11.	IDE 611	Water Resources Economics and Auditing	3(2+1)
12.	IDE 693*	Special Problem	1(0+1)
13.	IDE 694*	Case Study	1(0+1)

*** Compulsory**

B) Minor subjects (Min. 8 credits)

Sr. No.	Course No.	Course Title	Credits
1.	AE 601	Environmental Impact Assessment	3(1+2)
2.	AE 602	Climate Change Impact, Adaptation and Mitigation	3(2+1)
3.	AE 603	Research Techniques	3(2+1)
4.	AE 604	Bench Marking and performance Analysis	3(2+1)
5	SWCE 605	Hydrological Models	3(2+1)

C) Supporting subjects (Min. 5 credits)

Sr. No.	Course No.	Course Title	Credits
1.	BSCT 601	Object Oriented Programming	3(2+1)
2.	MATH 601	Mathematical Modelling and Software Applications	3(1+2)
3.	STAT 609	Operations Research	3(2+1)
4.	STAT 610	Probabilistic Approach in Design	2(2+0)
5.	STAT 611	Geostatistical Analysis	2(1+1)

D) Seminars (2 credits)

Sr. No.	Course No.	Course Title	Credits
1.	IDE 691	Seminar I	1(0+1)
2.	IDE 692	Seminar II	1(0+1)

E) Doctoral Research (45 credits)

Sr. No.	Course No.	Course Title	Credits
1.	IDE 699	Doctoral Research	45(0+45)

F) Non credit Compulsory courses*

Sr. No.	Course No.	Course Title	Credits
1.	PGS 501	Library and Information Services	1(0+1)
2.	PGS 502	Technical Writing and Communications Skills	1(0+1)
3.	PGS 503 (e-Course)	Intellectual Property and its Management in Agriculture	1(1+0)
4.	PGS 504	Basic Concepts in Laboratory Techniques	1(0+1)
5.	PGS 505 (e-Course)	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)
6.	PGS 506 (e-Course)	Disaster Management	1(1+0)

* exempted if completed in Masters degree

Laboratories:

A) Fluid Mechanic and Hydraulics Laboratory:

Sr. No.	Instrument / Equipment	Purpose
1	Venturimeter	To estimate discharge through pipes
2	Orifice meter	To estimate discharge through pipes
3	Hydraulic ram	Lifting of water using no conventional energy source
4	Weir and notches	To estimate discharge through channels
5	Bernoullis theorem	To verify Bernoulli's theorem
6	Coefficient of friction for flow through pipes	To determine coefficient of friction for flow through pipes
7	Bourden pressure gauge	To understand construction and working of pressure gauge
8	U tube manometer	To determine pressure between two different points
9	Apparatus for Cd, Cv& Cc	To determine Cd, Cv, & Cc
10	Metacentric height	To determine metacentric height of floating bodies
11	Reynolds apparatus	To study type of flow

Fluid Mechanic & Hydraulics Laboratory

A) Hydroinformatics Laboratory

Sr. No.	Instrument / Equipment	Purpose
1	Automatic leaf area meter	To calculate leaf area index
2	Portable Gas photosynthesis system	To measure photosynthesis rate of plant
3	Differential GPS	For land survey
4	Co_2 Analyzer	To measure Co_2 concentration in the soil
5	Plant canopy Analyser	To measure plant canopy

6	Root scanner	To measure root length
7	TDR soil moisture meter	To measure soil moisture content
8	Spectroradiometer- GER-1500 (350 to 1050 nm)	To take spectral signature & calculation of NDVI
9	Spectroradiometer- SVR-1024 (350 to 2500nm)	To take spectral signature & calculation of NDVI
10	Lux meter	To measure solar radiation intensity
11	Plant water status console	To measure leaf water potential
12	Pressure membrane plate apparatus	To measure PWP & FC of soil sample

Hydroinformatics Laboratory

C) Field Drainage Laboratory:

1. Post hole anger	To determine hydraulic conductivity
2. Sand tank model	To determine drainable porosity
3. Piezometer	To determine hydrostatic pressure
4. Oven	Drying of soil samples and use for determination of moisture content

B) Remote Sensing and GIS

Sr.No.	**Name of the Software**
Software	
1.	Arc GIS 9.3 with 10 license copies
2.	ERDAS IMAGINE 9.1
3.	Surfer 10
4.	METLAB 2011b
5.	FEFLOW
6.	MIKE SHE 11
7.	GNSS Solutions for DGPS
8.	Mobile Mapper Cx

Hardware	
1.	20 Computer systems
2.	Magic Studio as Audio-Visual Aid

Remote sensing and GIS Laboratory

E) Instructional Farm Laboratory :

1. Poly house	Research & Demonstration for the study on protective cultivation for vegetables & flowers.
2. Shade net house	Research & Demonstration
3. Automatic weather station	To automatically record climatological parameters & use those for estimation of water requirement of the crop.
4. Open dug well	Irrigation source

Instructional Farm

The Instructional Farm of the Department of Irrigation and Drainage engineering, Dr. A. S. Shinde College of Agricultural Engineering, Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra), India situated between 1947 and 1957 N latitude and 74,84 and 74,19 E longitudes. The altitude of the place is 667 meters above mean sea level.

Dept. of IDE Instructional Farm

Infrastructure

- Available water source: Open dug well
- Available irrigation system: Drip, mini sprinkler, micro sprinkler, Sprinkler, Raingun
- Water measurement devices: Notches weirs, flumes and water meter
- Polyhouse : one
- Shadenet house : four (Different colours and shading percentage of shadenets)
- Fertigation unit: injection pump and venturi system.

Water source- Open dug well

Control head for Micro Irrigation System

Projects Completed by Students

M. Tech. (Irrigation and Drainage Engineering)

Sr. No.	Name of M. Tech. Student	Name of Guide	Title of the M. Tech. Thesis	Year
1.	Mr. J. S. Phadare	Dr.P.S.Pampattiwar	Studies of moisture distribution pattern in trickle irrigation	1985
2.	Mr. S.D. Dahiwalkar	Dr.P.S.Pampattiwar	Studies on crop production function in relation with irrigation	1986
3.	Mr. A. K. Singh	Dr.P.S.Pampattiwar	Hydraulics of trickle irrigation	1987
4.	Mr. N.N. Firke	Dr.P.S.Pampattiwar	Field evaluation of steady & transient drain spacing equation	1987
5.	Mr. S.M. Lagad	Dr.P.S.Pampattiwar	Emitted and lateral tubing hydraulics in trickle irrigation	1989
6.	Mr. H.D. Kamble	Dr.P.S.Pampattiwar	Trickle irrigation screen filter performance as affected by sand size and concentration	1989
7.	Mr. J.K. Kumar	Dr.P.S.Pampattiwar	Hydraulics and moisture distribution pattern in BI wall subsurface irrigation	1990
8.	Mr. V.R. Salve	Dr.P.S.Pampattiwar	Optimal operational policy for	1992

			musalwadi section - 1 of mula left bank canal	
9.	Mr. M.C. Bankar	Dr.P.S.Pampattiwar	Drip irrigation performance for summer chilli	1992
10.	Mr. M.S. Mane	Dr.P.S.Pampattiwar	Reclamation of partially clogged trickle irrigation system	1992
11.	Mr. S.D. Ingale	Dr.P.S.Pampattiwar	Probelistic analysis of climatological parameters for estimation of irrigation water requirement for konkan region	1993
12.	Mr. S.B. Pathare	Dr.P.S.Pampattiwar	Design of micro sprinkler system based on uniformity in sprinkler	1993
13.	Mr. T.A. Mane	Dr.P.S.Pampattiwar	Evaluation of continuous and sugar flow furrow irrigation	1994
14.	Mr. C. Y. Pawar	Dr.P.S.Pampattiwar	Yield response of garlic (alium sativum l.) to micro sprinkler irrigation operated by solar photovoltaic pumping system	1995
15.	Shri.U.R.Shinde	Dr. N. N. Firake	Moisture and salinity status under different micro-irrigation systems in vertisols	1995
16.	Shri.K.T.Kadlag	Dr. N. N. Firake	Water requirement and yield of chilli under micro-irrigation systems and mulches	1995
17.	Mr. U.S. Kadam	Dr.P.S.Pampattiwar	Effect of frequency of irrigation on yield of Kharif groundnut (arachis s hypogea l) with solar photovoltaic operator micro sprinkler system	1996
18.	Mr. S.B. Jadhav	Dr. R.S. Dhotre	Field evaluation of seepage losses through canal network	1996
19.	Mr. S.N. Jadhav	Dr.P.S.Pampattiwar	Influence of irrigation frequency and amount of irrigation on yield of chilli under micro sprinkler irrigation operated by solar photovoltaic pumping system	1997
20.	Mr. R. G. Bhagyawan	Dr. R.S. Dhotre	Studies on reliability of resistivity method for groundwater prospecting in hard rock areas	1997
21.	S. O. Chopade	Dr. S.D.Gorantiwar	Effect of drip, bubbler and surface irrigation on yield and quality of pomegranate	1997
22.	Mr. P.P. Baviskar	Dr.L.V.Pingle	Effiect of water soluble fertilizers through drip on growth, yield and quality of suru sugarcane Co-86032	1998
23.	P. B. Kutwal	Dr. S.D.Gorantiwar	Irrigation scheduling and development of soil water balance-crop growth model for maize	1998

24.	Shri.D.R.Gite	Dr. N. N. Firake	Evaluation of different micro-irrigation systems and layouts for rabi onion	1998
25.	Shri.N.S.Mane	Dr. N. N. Firake	Response of sunflower to different micro-irrigation systems and irrigation levels in summer	1998
26.	Mr. S.A. Kadam	Dr.P.S.Pampattiwar	Effect of fertigation on the system performance	1999
27.	D. T. Gaikwad	Dr. S.D.Gorantiwar	Hydraulics of drip irrigation on sloping lands	1999
28.	Shri.S.T.Jadhav	Dr. N. N. Firake	Suitability of drip irrigation scheduling approach for summer groundnut	1999
29.	Shri.M.G.Mahale	Dr. N. N. Firake	Standardization of layouts of different micro-irrigation systems in *kharif* soybean	1999
30.	Mr. H.M. Galgale	Dr.L.V.Pingale	Indicated land and water resources development	2000
31.	Y. R. Godase	Dr. S.D.Gorantiwar	Alternative crop plans for Mula command area using remote sensing and GIS techniques	2000
32.	Shri. D.R.Nikam	Dr. N. N. Firake	Effect of planting layouts and micro-irrigation systems on growth and yield of summer groundnut	2000
33.	Shri.D.B.Kumbhar	Dr. N. N. Firake	Effect of levels of solid soluble fertilizers through drip system on yield and quality of pomegranate	2000
34.	Shri.R.B.Gole	Dr. N. N. Firake	Effect of micro-irrigation systems and nitrogen fertigation levels on yield and quality of summer onion	2000
35.	Mr. P. S. Sharma	Dr.P.S.Pampattiwar	Studies on hydraulic performance evaluation of different types of micro sprinkler	2001
36.	Miss. Patil S. M.	Dr.P.S.Pampattiwar	Field performance evaluation of micro sprinkler irrigation system	2001
37.	Miss. Manjurima Gogoi	Dr. N. N. Firake	Efficacy of floppy sprinkler irrigation method for onion	2001
38.	Miss.K.R.Choudhari	Dr. N. N. Firake	Evaluating of wetted factor for drip irrigated brinjal in summer	2001
39.	Shri.S.J.Pawar	Dr. N. N. Firake	Effect of irrigation levels and micro-irrigation methods on quality and yield of cabbage	2001
40.	Shri.S.A.Chougule	Dr. N. N. Firake	Hydraulics of drip irrigation in built emitter lines	2002
41.	Shri.G.D.Mali	Dr. N. N. Firake	Trickle irrigation and fertilizer uniformity with PC and NPC emitters in different layouts	2002
42.	Mr. N.L. Bangar	Dr.R.S.Dhotre	Field performance of subsurface irrigation system (corus pipe for	2003

			tomato)	
43.	P. M. Ingle	Dr. S.D.Gorantiwar	Studies on performance of different operation schedules in canal command area of Nazare Medium Irrigation Project using RS and GIS techniques	2003
44.	S. J. Dagade	Dr. S.D.Gorantiwar	Optimum utilization of land and water resources in canal command area of Nazare Medium Irrigation Project using RS and GIS techniques	2003
45.	Shri.P.S.Deshmukh	Dr. N. N. Firake	Evaluation of surge flow irrigation for green gram (*Vigna radiate* L.) on clay soil	2003
46.	Shri.D.S.Chaure	Dr. N. N. Firake	Hydraulics and moisture distribution pattern in subsurface porous pipe irrigation	2003
47.	Mr. B.K. Rajput	Dr.R.S.Dhotre	Hydraulic studies and performance evaluation of subsurface porous pipe irrigation system for sugarcane	2004
48.	Miss. A.M.Sul	Dr. N. N. Firake	Irrigation scheduling for whet in floppy sprinkler irrigation	2004
49.	Miss.S.D.Mahajan	Dr. N. N. Firake	Effect of micro-irrigation systems and mulch on growth and yield of *rabi* sunflower and its economics	2004
50.	Mr. S.A. Wagh	Dr. S.D. Dahiwalkar	Design and testing of sand and gravel filter for artificial groundwater recharge	2005
51.	Mr. G.L. Borse	Dr.R.S.Dhotre	Field evaluation of porous pipe subsurface irrigation system for sugarcane	2006
52.	Shri.K.H.Baviskar	Dr. N. N. Firake	Studies on comparative performance of sprinkler irrigation systems for wheat	2006
53.	Shri.A.B.M.Wijaytunga *(foreign student)*	Dr. N. N. Firake	Response of potato to trickle and sprinkler irrigation systems	2006
54.	Shri.A.G.Karunaratne *(foreign student)*	Dr. N. N. Firake	Efficiency of pressurized irrigation systems for late *kharif* onion	2006
55.	Miss. J.M.Mali	Dr. N. N. Firake	Effect of micro-irrigation systems and planting layouts on growth, yield and economics of garlic	2006
56.	P. D. Patil	Dr. S.D.Gorantiwar	Stochastic modeling of crop evapotranspiration for Rahuri region, (M.S.)	2007
57.	Shri.V.S.Mulay	Dr. N. N. Firake	Water production functions for potato under micro-jet and surface irrigation methods	2007
58.	Shri.M.S.Nijamudee	Dr. N. N. Firake	Effect of different mulches on	2007

	n *(foreign student)*		consumptive use, yield, quality and economics of *rabi* onion	
59.	Miss.N.B.Kanade	Dr. N. N. Firake	Yield response of cucumber to different mulches and irrigation levels under drip irrigation	2007
60.	S.U. Adsul	Dr. S.D.Gorantiwar	Hydraulics of raingun irrigation system	2008
61.	K. H. Patil	Dr. S.D.Gorantiwar	A model for allocation of water resources at basin level	2008
62.	A.P. Yawatkar	Dr. S.D.Gorantiwar	Development of irrigation water management model based on NDVI	2008
63.	Miss. M.G. Mane	Dr.R.S.Dhotre	Response of ratoon sugarcane to porous pipe subsurface irrigation method	2009
64.	A.L. Titkare	Dr. S.D.Gorantiwar	Stochastic modeling of stream flows of Mula river for generation and forecasting	2009
65.	Mr. V.M. Sali	Dr. S.D. Dahiwalkar	Effect of municipal waste water on groundwater groundwater quality for rahuri district Ahmednagar	2009
66.	Shendage A.S.	Dr.S.B.Gadge	Hydraulic Studies of Different Microsprinklers	2009
67.	Miss. Jadhav Vaishali	Dr.R.S.Dhotre	Influence of deficit irrigation on wheat production under semi arid conditions	2010
68.	R. V. Patil	Dr. S.D.Gorantiwar	Studies on reference crop evapotranspiration and water deficit for Rahuri	2011
69.	H. M. Palkar	Dr. S.D.Gorantiwar	Development of ndvi based decision support system for irrigation water management	2011
70.	Miss. Punam Borse	Dr. S.D. Dahiwalkar	Effect of groundwater polluted by municipal waste water on quality and yield of onion.	2011
71.	Patil M.A.	Dr.S.B.Gadge	Studies on yield response of cucumber to shading percentage of shadenet and fertigation	2012
72.	Y.D.Kamble	Dr. S.D.Gorantiwar	Deficit Irrigation Water Management for Wheat	2013
73.	Shaikh R.R.	Dr.S.B.Gadge	Optimal design of drip irrigation system	2013
74.	S.R.Satpute	Dr. S.D.Gorantiwar	Response of shednet colour, plant density and water application level on the yield and water use efficiency of marigold	2015
75.	Y. Raut	Dr. S.D.Gorantiwar	Deficit irrigation for onion by drip method in polyhouse, shednethouse and open field	2014

			conditions.	
76.	P.S.Ghule	Dr. S.D.Gorantiwar	Water allocation for a sub catchment in Bhima River basin using MIKE BASIN model	2014
77.	Mr. D.S. Rajput	Dr. S.D.Dahiwalkar	Effect of polluted groundwater by industrial influent on quality and yield of cabbage	2014
78.	Mr. N.A. Marale	Dr. S.D.Dahiwalkar	Effect of pollutated groundwater due to sugar factory effluent on yield of wheat crop and soil properties	2014
79.	Mr. H.D. Chaudhari	Dr. S.D.Dahiwalkar	Effect of mulches on tomato under different drip irrigation regions	2014
80.	Jadhao A.R.	Dr.S.B.Gadge	Yield response of Cucumber to fertigation under shade net house	2014
81.	Mr. Y.D. Kamble	Prof. D.D. Khedkar	Deficit irrigation water management for wheat	2014
82.	Mr. A.V. Shejul	Prof. D.D. Khedkar	Response of irrigation and fertigation levels on yield of green pea	2014
83.	S.S. Dhangar	Dr. S.D.Gorantiwar	Development of decision support system for optimization of farm pond size	2015
84.	H.S. Sarode	Dr. S.D.Gorantiwar	Effect of different water stress on yield performance of onion crop	2015
85.	Takale S.S.	Dr.S.B.Gadge	Cucumber response to mulch and irrigation levels under photo selective shading nets	2015
86.	S. S. Kadam	Dr. S. A. Kadam	Crop coefficient (Kc) and vegetation index (VI) relationships for wheat based on remote sensing approach for irrigation water management	2015
87.	Shri.V.D.Paradkar	Dr. N. N. Firake	Effect of different colour plastic mulches on growth and yield of banana crop	2016
88.	Poornima	Dr.S.B.Gadge	Yield response of drip irrigated cucumber to mulch and irrigation regimes under different shading nets	2016
89.	Miss.S.S.Patil	Dr. N. N. Firake	Response of Broccoli (*Brassica oleracea L. var.italic*) to different levels of irrigation and fertigation under different colour shadenets in *rabi* season.	2017
90.	Rokade P.S.	Dr.S.B.Gadge	Muskmelon response to irrigation levels and plastic mulch under shading nets	2017
91.	D. P. Tale	Dr. S. A. Kadam	Deficit irrigation for potato	2017

			production under semi-arid condition	
92.	B.B. Rathod	Dr. S.D.Gorantiwar	Deficit Irrigation for tomato production under Semi Arid condition	2018
93.	Shri.H.S.Ulape	Dr. N. N. Firake	Response of Red cabbage (*Brassica oleracea* L.) to different irrigation and fertigation regimes under varying shading percentages.	2018
94.	Utkhede A.D.	Dr.S.B.Gadge	Response of Muskmelon to spectral modification and irrigation levels under shading nets	2018
95.	N. P. Mandre	Dr. S. A. Kadam	Crop coefficient and yield response factor for *rabi* potato (*Solanum Tuberosum* L.) under deficit irrigation	2018
96.	Shri.Vishal Pandy	Dr. N. N. Firake	Response of Red cabbage to different irrigation and fertigation regimes under polyhouse and open field during late *kharif* season.	2019

Ph. D (Irrigation and Drainage Engineering)

Sr. No.	Name of the Ph D student	Guide	Title of the Ph. D. Thesis	Year
1.	S.A.Kadam	Dr. S.D.Gorantiwar	Spatial Decision Support System based on Remote Sensing Approach for Irrigation Water Management	2014
2.	Mr. R.G. Bhagyawant	Dr. S.D. Dahiwalkar	Deficit irrigation for rabi onion production under semi arid condition	2014
3.	N.N.Firake	Dr. S.D.Gorantiwar	Response of Capsicum (*Capsicum annum* L.) to Different Irrigation Regime under Protected Cultivation	2016
4.	P.G.Popale	Dr. S.D.Gorantiwar	Forecasting & Generation of Weekly Rainfall using Stochastic model & ANN Techniques	2016
5.	A.D. Bhagat	Dr. S.D.Gorantiwar	Spatial Decision Support System for Irrigation Water Management in Context of Climate Variability & Change	2017
6.	Mr. S.D. Rathod	Dr. S.D. Dahiwalkar	Optimization of subsurface drain specing and depth for sugarcane (Soccharum officinarum l.) under water logged verticals.	2017

7.	Miss. P. S. Wankhede	Dr. S.D. Dahiwalkar	Comparative performance of tomato (solanum lycopersicum l) to different irrigation regions under protected cultivation and open field	2018
8.	P. B. Jadhav	Dr. S.D.Gorantiwar	Decision Support System for Optimization of Conjunctive Utilization of Surface and Ground Water	2019
9.	V.R.Mandve	Dr. S.D.Gorantiwar	Irrigation Management of Command Area using MIKE models	2019
10.	Er. S. K. Dingre	Dr. S.D.Gorantiwar	Deficit irrigation for sugarcane under semi-arid conditions	2019

Research Recommendation

Over the years, this group has developed several technologies in the form of 69 recommendations. These include:

- Irrigation scheduling for drip, sprinkler and subsurface porous pipe irrigation systems
- Fertigation scheduling for different crops
- Hydraulics of pressurised irrigation systems (drip, microsprinkler, sprinkler, subsurface porous pipe, raingun) leading to design of these systems
- Drainage coefficients for different Tahsils of western Maharashtra
- Crop coefficients for wheat, gram, onion, safflower, sorghum, sweet corn, onion, soybean
- Yield response factors for onion and wheat
- Subsurface and mole drainage technologies
- Evapotransipration, water and irrigation water requirement of different crops for the western Maharashtra
- IT Technologies such as web based and mobile applications for irrigation scheduling and management such as , Phule Jal, Phule Irrigation Scheduler
- Decision Support System for the irrigation water management an farm pond design
- Meteorological and agricultural draught estimation for different crops
- Simulation and optimisation models for the optimum utilisation of water, the land and water resources development plans on watershed and command area basis using RS and GIS techniques
- Groundwater recharge techniques
- Response of different crops under protected cultivation of polyhouse, shadnet houses of different colours and shading percentage
- Mulch technology for different crops.

Thrust areas

- Simulation models and decision support systems (DSS) for irrigation water management
- Optimum and conjunctive utilisation of water resources using conventional optimisation (linear, dynamic and non linear programming) and soft computing techniques (Genetic algorithm, particle swarm optimisation, ant colony optimisation)
- Influence of climate changes on the availability and demand of water for irrigation
- Development of crop coefficient for different crops
- Studies on trends of evapotranspiration
- Application of Remote Sensing (RS), Geographical Information System (GIS) and Global Positioning Systems (GPS) for management of water resources
- Precision farming using GIS and GPS technologies
- IT technologies including web based and mobile applications
- Irrigation water management and environment control in controlled environment (polyhouses and shadenet houses)
- Subsurface drainage technologies: design and adoption to different crops in different water logging and salinity scenario
- Irrigation scheduling for different crops using different irrigation methods
- Optimum design of pressurised irrigation methods (sprinkler and microirrigation) by hydraulic, computational and simulation studies
- Development, testing and application of different groundwater recharge techniques
- Groundwater pollution assessment
- Use of polluted groundwater and waste water for irrigation
- Optimisation of groundwater utilisation
- Adoption of pressurised irrigation methods on canal command area
- Multicriteria decision making in irrigation water management
- Water Users' Association

Details of Research Recommendations

1. **Irrigation Scheduling for Pomegranate (1990)**
   Amount of water to be applied to each pomegranate plant through drip method of irrigation should be worked out on the basis of 80% of daily pan evaporation and 20% of allotted area when the plants are spaced 4 x 3 m in light soil for higher water use efficiency, water saving and maximum fruit yield.

2. **Irrigation Scheduling for Lime (1990)**
   Amount of water to be applied to each lime plant through drip method of irrigation should be worked out on the basis of 80% of daily pan evaporation and 20% of allotted area when the plants are spaced 4 x 3 m in light soil for higher water use efficiency, water saving and maximum fruit yield.

3. **Irrigation Scheduling for Bhendi (1991)**
   Amount of water to be applied to summer (January to April) Bhendi planted at the spacing of 15 cm x 30 cm through drip irrigation should be worked out on the basis of 80% of daily pan evaporation and 60% of allotted area in clayey soil for maximum yield.

4. **Subsurface Porous Pipe Irrigation System for Sugarcane (2008)**
   Considering the advantages of water saving and energy saving as well as ease of operation, the porous pipe subsurface irrigation system is recommended for sugarcane. For paired row plantation of sugarcane at 75 x 150 cm in medium black soil, the porous pipe laterals should be buried 20 cm below soil surface between a sugarcane rows. The maximum length of porous pipe should not exceed 50 m for water storage tank 2 m above the surface.

5. **Crop coefficient of wheat (2011)**
   The following table is recommended for computing the crop coefficients required for the estimation of water requirement of wheat.

Week after sowing	Method of estimation of reference crop evapotranspiration (ETr)		
	Penman Monteith	Pan Evaporation	Hargreaves-Samani
1	0.71	0.84	0.70
2	0.88	1.11	0.86
3	1.03	1.29	0.98
4	1.15	1.40	1.08
5	1.24	1.46	1.17
6	1.31	1.50	1.24
7	1.36	1.51	1.28
8	1.38	1.51	1.31
9	1.36	1.47	1.31
10	1.31	1.41	1.27
11	1.22	1.31	1.20
12	1.10	1.17	1.10
13	0.94	1.00	0.95
14	0.76	0.79	0.78
15	0.57	0.58	0.59
16	0.39	0.37	0.40
17	0.22	0.20	0.22

Alternatively following equations are recommended
Penman-Monteith method:

$$Kc_t = 10.092\left(\frac{t}{T}\right)^5 - 20.039\left(\frac{t}{T}\right)^4 + 12.871\left(\frac{t}{T}\right)^3 - 7.0936\left(\frac{t}{T}\right)^2 + 3.7412\left(\frac{t}{T}\right) + 0.5942$$

Pan evaporation method:

$$Kc_t = 23.473\left(\frac{t}{T}\right)^5 - 58.125\left(\frac{t}{T}\right)^4 + 53.101\left(\frac{t}{T}\right)^3 - 26.28\left(\frac{t}{T}\right)^2 + 7.3589\left(\frac{t}{T}\right) + 0.6251$$

Hargreaves-Samani method:

$$Kc_t = 11.758\left(\frac{t}{T}\right)^5 - 25.21\left(\frac{t}{T}\right)^4 + 17.526\left(\frac{t}{T}\right)^3 - 7.9392\left(\frac{t}{T}\right)^2 + 3.4207\left(\frac{t}{T}\right) + 0.6008$$

Where
Kc_t is the crop coefficient of wheat on t^{th} day; t is day and T is total crop growth period in days

6. Crop coefficient of gram (2011)

The following table is recommended for computing the crop coefficients required for the estimation of water requirement of gram.

Week after sowing	Method of estimation of reference crop evapotranspiration (ETr)		
	Penman Monteith	**Pan Evaporation**	**Hargreaves-Samani**
1	0.85	0.77	**0.83**
2	0.84	0.75	**0.79**
3	0.88	0.79	**0.80**
4	0.95	0.86	**0.83**
5	1.04	0.95	**0.89**
6	1.12	1.04	**0.95**
7	1.18	1.11	**1.01**
8	1.21	1.15	**1.05**
9	1.20	1.15	**1.06**
10	1.15	1.10	**1.04**
11	1.05	1.01	**0.97**
12	0.91	0.88	**0.86**
13	0.75	0.72	**0.72**
14	0.57	0.53	**0.55**
15	0.38	0.35	**0.37**
16	0.23	0.19	**0.21**
17	**0.12**	**0.09**	**0.11**

Alternatively following equations are recommended
Penman-Monteith method:

$$Kc_t = 2.3266\left(\frac{t}{T}\right)^5 + 8.5503\left(\frac{t}{T}\right)^4 - 24.573\left(\frac{t}{T}\right)^3 + 14.708\left(\frac{t}{T}\right)^2 - 1.8175\left(\frac{t}{T}\right) + 0.8965$$

FAO-24 pan evaporation method:

$$Kc_t = 4.6054\left(\frac{t}{T}\right)^5 + 3.7237\left(\frac{t}{T}\right)^4 - 21.598\left(\frac{t}{T}\right)^3 + 14.449\left(\frac{t}{T}\right)^2 - 1.9212\left(\frac{t}{T}\right) + 0.8186$$

Hargreaves-Samani method:

$$Kc_t = 11.846\left(\frac{t}{T}\right)^5 - 17.134\left(\frac{t}{T}\right)^4 - 1.0715\left(\frac{t}{T}\right)^3 + 7.0215\left(\frac{t}{T}\right)^2 - 1.4371\left(\frac{t}{T}\right) + 0.8635$$

Where

Kc_t is the crop coefficient of wheat on t^{th} day; t is day and T is total crop growth period in days

7. Artificial groundwater recharge through percolation tanks (2011)

It is recommended to consider a distance of 600 m to estimate the groundwater potential around the percolation tanks constructed in hard rock region of Western Maharashtra.

8. Crop coefficient of *Kharif* Sorghum (2012)

The crop coefficients given in following table are recommended for the estimation of water requirement of *Kharif* Sorghum.

Week after sowing	Method of estimation of reference crop evapotranspiration (ETr)		
	Penman-Monteith	Hargreaves-Samani	Pan evaporation
1	0.59	0.63	**0.64**
2	0.63	0.70	**0.70**
3	0.82	0.68	**0.69**
4	0.56	0.63	**0.62**
5	0.84	1.01	**0.99**
6	0.81	1.05	**1.12**
7	1.05	1.10	**1.10**
8	1.22	0.98	**1.04**
9	1.19	1.25	**1.27**
10	1.11	1.10	**1.07**
11	1.24	1.07	**1.07**
12	1.45	1.09	**1.06**
13	1.56	1.29	**1.41**
14	1.31	1.23	**1.25**
15	0.97	1.00	**0.97**
16	**0.37**	**0.58**	**0.58**

Alternatively following equations are recommended

Penman-Monteith method:

$$Kc_t = 34.945\left(\frac{t}{T}\right)^5 - 91.679\left(\frac{t}{T}\right)^4 + 76.635\left(\frac{t}{T}\right)^3 - 23.547\left(\frac{t}{T}\right)^2 + 3.2158\left(\frac{t}{T}\right) + 0.5443$$

Hargreaves-Samani method:

$$Kc_t = -29.787\left(\frac{t}{T}\right)^5 + 68.045\left(\frac{t}{T}\right)^4 - 58.551\left(\frac{t}{T}\right)^3 + 21.521\left(\frac{t}{T}\right)^2 - 1.8223\left(\frac{t}{T}\right) + 0.6581$$

Pan evaporation method:

$$Kc_t = -31.891\left(\frac{t}{T}\right)^5 + 73.525\left(\frac{t}{T}\right)^4 - 63.715\left(\frac{t}{T}\right)^3 + 23.539\left(\frac{t}{T}\right)^2 - 2.0681\left(\frac{t}{T}\right) + 0.6646$$

Where

Kc_t is the crop coefficient of *Kharif* Sorghum on t^{th} day; t is day and T is total crop growth period in days

9. Crop coefficient of *Rabi* Sorghum (2012)

The crop coefficients given in following table are recommended for the estimation of water requirement of *Rabi* Sorghum.

Week after sowing	Method of estimation of reference crop evapotranspiration (ETr)		
	Penman-Monteith	Hargreaves-Samani	Pan evaporation
1	0.42	0.40	0.45
2	0.61	0.55	0.55
3	0.64	0.57	0.62
4	0.71	0.74	0.75
5	0.70	0.69	0.73
6	0.87	0.94	0.85
7	1.17	1.15	1.36
8	1.03	1.00	1.12
9	1.03	0.99	1.06
10	1.00	0.91	1.07
11	0.82	0.76	0.86
12	0.77	0.72	0.88
13	0.87	0.81	0.96
14	0.76	0.77	0.77
15	0.73	0.71	0.82
16	0.86	0.87	0.87
17	0.67	0.69	0.76
18	0.56	0.54	0.59
19	0.36	0.35	0.37
20	0.31	0.32	0.31

Alternatively following equations are recommended

Penman-Monteith method:

$$Kc_t = -22.954\left(\frac{t}{T}\right)^5 + 57.946\left(\frac{t}{T}\right)^4 - 50.496\left(\frac{t}{T}\right)^3 + 14.968\left(\frac{t}{T}\right)^2 + 0.3574\left(\frac{t}{T}\right) + 0.44$$

Hargreaves-Samani method:

$$Kc_t = -27.595\left(\frac{t}{T}\right)^5 + 67.298\left(\frac{t}{T}\right)^4 - 55.826\left(\frac{t}{T}\right)^3 + 15.345\left(\frac{t}{T}\right)^2 + 0.6384\left(\frac{t}{T}\right) + 0.3885$$

Pan evaporation method:

$$Kc_t = -33.863\left(\frac{t}{T}\right)^5 + 86.791\left(\frac{t}{T}\right)^4 - 77.74\left(\frac{t}{T}\right)^3 + 25.476\left(\frac{t}{T}\right)^2 - 0.8817\left(\frac{t}{T}\right) + 0.4602$$

Where

Kc_t is the crop coefficient of *Rabi* Sorghum on t^{th} day; t is day and T is total crop growth period in days

10. Development of Software for computation of water requirement (2012)

The user friendly "*Phule Jal*" computer software developed by Mahatma Phule Krishi Vidyapeeth is recommended for the computation of the reference evapotranspiration based on climatological approach.

11. Development of Software for design and adoption of micro irrigation methods in command area (2012)

Designing and adoption of microirrigation systems using a model "*Phule Sukshma Sinchan Arekhan*" developed by Mahatma Phule Krishi Vidyapeeth is recommended in the command area of irrigation project under rotational water supply (*Shejpali*) system.

12. Development of filter for groundwater recharge (2012)

The four layer filter as specified below is recommended for recharging wells with higher filtration efficiency as given below.

Filter layer No.	Filter layer thickness (top to bottom)	Filter material and its size
1	15 cm	Coal grade -I (4.00 to 8.00 mm)
2	45 cm	Sand grade -I (0.6 to 2.00 mm)
3	45 cm	Pea gravel grade -I (2.00 to 6.00 mm)
4	45 cm	Angular gravel grade -I (9.5 to 15.5 mm)

13. Mole drainage system for subsurface drainage (2012)

The "mole drainage" system with 4.0 m mole spacing and 0.60 m depth is recommended for effective drainage and to obtain higher crop yield from ill drained deep black soils.

14. Crop coefficient of Safflower (2013)

The crop coefficients given in following table are recommended for the estimation of water requirement of Safflower.

Week since sowing	Kc values		
	Penman-Monteith Method	Hargreaves-Samani Method	Pan evaporation Method
1	0.25	0.22	**0.22**
2	0.36	0.31	**0.30**
3	0.60	0.52	**0.48**
4	0.88	0.77	**0.67**
5	1.11	0.98	**0.83**
6	1.27	1.12	**0.95**
7	1.33	1.17	**1.01**
8	1.30	1.14	**1.01**
9	1.20	1.04	**0.97**
10	1.05	0.90	**0.88**
11	0.88	0.75	**0.78**
12	0.73	0.62	**0.69**
13	0.61	0.53	**0.60**
14	0.55	0.49	**0.54**
15	0.53	0.49	**0.50**
16	0.53	0.51	**0.47**

17	0.50	0.49	**0.42**
18	**0.35**	**0.34**	**0.29**

Alternatively following equations are recommended

Penman-Monteith method:

$$Kc_t = -80.082\left(\frac{t}{T}\right)^5 + 204.93\left(\frac{t}{T}\right)^4 - 179.02\left(\frac{t}{T}\right)^3 + 56.487\left(\frac{t}{T}\right)^2 - 2.4253\left(\frac{t}{T}\right) + 0.2774$$

Hargreaves-Samani method:

$$Kc_t = -80.06\left(\frac{t}{T}\right)^5 + 202.65\left(\frac{t}{T}\right)^4 - 175.3\left(\frac{t}{T}\right)^3 + 55.41\left(\frac{t}{T}\right)^2 - 2.8415\left(\frac{t}{T}\right) + 0.2621$$

Pan evaporation method:

$$Kc_t = -46.874\left(\frac{t}{T}\right)^5 + 121.37\left(\frac{t}{T}\right)^4 - 107.96\left(\frac{t}{T}\right)^3 + 34.53\left(\frac{t}{T}\right)^2 - 1.1234\left(\frac{t}{T}\right) + 0.2255$$

Where

Kc_t is the crop coefficient of Safflower on t^{th} day; t is day and T is total crop growth period in days

15. Development of software for irrigation scheduling by drip irrigation (2013)

The user friendly computer software, "*Phule Drip Irrigation Scheduler*" developed by Mahatma Phule Krishi Vidyapeeth is recommended for suitable irrigation scheduling based on climatological approach by drip method.

16. Drainage coefficients for Rahuri region (2013)

The drainage coefficient (mm) values given in following table are recommended for the design of surface drainage system for Rahuri area.

Basic infiltration rate (mm/hr)	DC for one day rainfall for R.I.(years)			DC for two day rainfall for R.I.(years)			DC for three days rainfall for R.I.(years)			DC for four days rainfall for R.I.(years)			DC for five days rainfall for R.I.(years)		
	2	5	10	2	5	10	2	5	10	2	5	10	2	5	10
1.0	41	65	81	17	34	46	8	21	29	2	14	21	-	10	17
2.0	17	41	57	-	10	22	-	-	5	-	-	-	-	-	-
3.0	-	17	33	-	-	-	-	-		-	-	-	-	-	-
4.0	-	-	9	-	-	-	-	-		-	-	-	-	-	-

17. Deficit irrigation for wheat (2013)

Irrigation @ 90% crop evapotranspiration (ETc) at an interval of two weeks is recommended under limited water availability for obtaining higher wheat yield.

18. Drainage coefficients for Sangli District (2014)

The drainage coefficient values developed by Mahatma Phule Krishi Vidyapeeth are recommended for the design of surface drainage system for different Tahsils of Sangli district. Alternatively the maps developed in Geographical Information System (GIS) are recommended for estimating the drainage coefficient values for Sangli district.

19. Drainage coefficients for Solapur District (2014)

The drainage coefficient values developed by Mahatma Phule Krishi Vidyapeeth are recommended for the design of surface drainage system for different Tahsils of Solapur district. Alternatively the maps developed in Geographical Information System (GIS) are recommended for estimating the drainage coefficient values for Solapur district.

20. Crop coefficient of Soybean (2014)

The crop coefficients given in following table are recommended for the estimation of water requirement of Soybean.

Week since sowing	Kc values	
	Penman-Monteith Method	Hargreaves-Samani Method
1	0.51	**0.34**
2	0.57	**0.35**
3	0.66	**0.41**
4	0.76	**0.51**
5	0.86	**0.61**
6	0.95	**0.71**
7	1.02	**0.79**
8	1.08	**0.84**
9	1.10	**0.87**
10	1.09	**0.86**
11	1.05	**0.82**
12	0.98	**0.77**
13	0.80	**0.89**
14	0.80	**0.65**
15	0.71	**0.62**
16	**0.65**	**0.63**

Alternatively following equations are recommended

Penman-Monteith method:

$$Kc_t = 2.647\left(\frac{t}{T}\right)^5 + 0.140\left(\frac{t}{T}\right)^4 - 8.761\left(\frac{t}{T}\right)^3 + 5.862\left(\frac{t}{T}\right)^2 + 0.260\left(\frac{t}{T}\right) + 0.494$$

Hargreaves-Samani method:

$$Kc_t = -0.752\left(\frac{t}{T}\right)^5 + 11.87\left(\frac{t}{T}\right)^4 - 22.35\left(\frac{t}{T}\right)^3 + 12.77\left(\frac{t}{T}\right)^2 - 1.258\left(\frac{t}{T}\right) + 0.366$$

Where

Kc_t is the crop coefficient of Soybean on t^{th} day; t is day and T is total crop growth period in days

21. Development of software for design of drip irrigation system (2014)

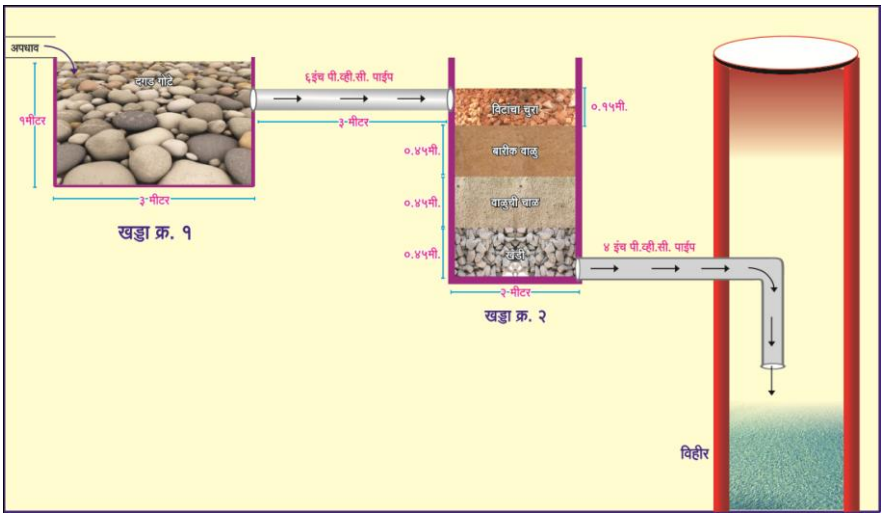
The user friendly "Phule Drip Irrigation System Designer" computer software developed by Mahatma Phule Krishi Vidyapeeth is recommended for optimal design and cost estimation of drip irrigation system.

22. Development of improved filter for groundwater recharge (2014)

The improved four layer filter is recommended for recharge of wells for obtaining more filtration efficiency as given below.

Specifications of four layer filter

Filter layer No.	Filter layer thickness (top to bottom)	Filter material and its size
1	15 cm	Brick flakes (30 to 40 mm)
2	45 cm	Sand grade I (0.6 to 2.00 mm)
3	45 cm	Pea gravel grade I (2.00 to 6.00 mm)
4	45 cm	Angular gravel grade I (9.5 to 15.50 mm)



23. Irrigation scheduling of Capsicum under shad net house (2014)

It is recommended to schedule irrigation daily @ 75% of crop evapotranspiration under shadenet house having shadnet of green color with 75% shading for obtaining maximum production and net returns of capsicum (October planting).

24. Fertigation of Capsicum in Naturally ventilated polyhouse (2014)

In naturally ventilated polyhouse, to obtain higher production of capsicum (October planting) with better quality and net returns, scheduling of daily drip irrigation @ 70% of crop evapotranspiration and alternate day fertigation @ 100% of recommended dose through water soluble fertilizers (before flowering: 8.0:2.8:4.0:2.8:0.2 kg ha^{-1} and after flowering : 6.0:3.0:15.0:3.0:0.3 kg ha^{-1} $N:P_2O_5:K_2O$:Ca:Mg) is recommended.

25. Fertigation scheduling of Cucumber under shad net house (2014)

The plantation of cucumber (January planting) in shadenet house of 75% shading and drip fertigation @ 125% of recommended dose (100:50:50 kg/ha) of soluble fertilizers, after 15 days of planting in 26 equal splits at 4 days interval is recommended for obtaining maximum yield.

26. Determination of Surface Drainage Coefficient through Rainfall Analysis for Nasik District (2015)

The following drainage coefficient (mm) values developed by Mahatma Phule Krishi Vidyapeeth, Rahuri are recommended for the design of surface drainage system for Tahsils of Nasik district. Alternatively the maps developed in GIS are recommended for estimating the drainage coefficient values.

27. Determination of Surface Drainage Coefficient through Rainfall Analysis for Satara District (2015)

The following drainage coefficient (mm) values developed by Mahatma Phule Krishi Vidyapeeth are recommended for the design of surface drainage system for Tahsils of Satara district. Alternatively the maps developed in GIS are recommended for estimating the drainage coefficient values

28. Deficit irrigation for *rabi* onion production under semi arid condition (2015)

Under deficit irrigation management, rabi onion should be irrigated with 20% less than required water during bulb initiation stage (i.e. 51 to 75 days after transplanting) to obtain maximum production of quality onion bulbs in medium deep soils of scarcity zone of Maharashtra.

29. Development of crop coefficient for *rabi* onion by field experimental method (2015)

The crop coefficients given in following table are recommended for the estimation of water requirement of onion

Week since transplanting	Kc values
1	0.63
2	0.69
3	0.73
4	0.79
5	0.85
6	0.92
7	1.00
8	1.08
9	1.15
10	1.20
11	1.23
12	1.21
13	1.14
14	1.01
15	0.81
16	0.54

Alternatively following equation is recommended

$$\mathbf{Kc = 8.062}\left(\frac{t}{T}\right)^{5} \mathbf{- 24.31}\left(\frac{t}{T}\right)^{4} \mathbf{+ 20.15}\left(\frac{t}{T}\right)^{3} \mathbf{- 5.761}\left(\frac{t}{T}\right)^{2} \mathbf{+ 1.498}\left(\frac{t}{T}\right) \mathbf{+ 0.561}$$

Where

Kc_t is the crop coefficient of onion on t^{th} day;

It is day and T is total crop growth period in days

30. Yield response factor for onion (Allium cepa. L) under deficit irrigation for semiarid tropics of Maharashtra. (2015)

Under deficit irrigation management the following yield response factors are recommended for estimating the yield of Rabi onion under different irrigation strategies.

1. Seasonal yield response function (Ky) (to be used in Doorenbos and Kassam equation) = 1.59
2. Stage wise yield response function (Ky) (to be used in Stewart equation) are

Vegetative stage	Ky1 (1-50 days)	= 0.654
Bulb initiation stage	Ky2 (51-75 days)	= 0.542
Bulb development stage	Ky3 (76-100 days)	= 0.305

31. Development of user friendly Decision Support System for Irrigation Water Management. (2015)

"Phule DSS-IWM" computer software developed by Mahatma Phule Krishi Vidyapeeth is recommended for deciding optimum irrigation water management based on expected yield and benefits for different crops.

32. Development of Crop Coefficients for Sweet Corn (2015)

The crop coefficients given in following table are recommended for the estimation of water requirement of sweet corn.

Week since sowing	Kc
1	0.61
2	0.58
3	0.63
4	0.71
5	0.80
6	0.87
7	0.91
8	0.91
9	0.89
10	0.83
11	0.77
12	0.70
13	0.63
14	0.60
15	0.59

Alternatively following equations are recommended

$$Kc_t = -8.523\left(\frac{t}{T}\right)^5 + 31.21\left(\frac{t}{T}\right)^4 - 38.39\left(\frac{t}{T}\right)^3 + 17.82\left(\frac{t}{T}\right)^2 - 2.174\left(\frac{t}{T}\right) + 0.659$$

Where

Kc_t is the crop coefficient of sweet corn on t^{th} day; t is day and T is total crop growth period in days

33. To study the effect of different irrigation levels for onion in shadenet house. (2015)

Cultivation of onion under shadenet house conditions is not recommended due to abnormal bulb development and economical yield.

34. Development of the technique for recharge of bore well. (2015)

The four layer filter is recommended for recharge of bore wells to obtain more filtration efficiency as given below.

Specifications of four layer filter

Filter layer No.	Filter layer thickness (top to bottom) (cm)	Filter material and its size (mm)
1	25	Brick flakes (24 to 28)
2	25	Sand grade I (0.6 to 2.00)
3	25	Angular gravel grade I (9.5 to 15.5)
4	25	Pea gravel grade I (20 to 24)

35. Effect of deficit irrigation and planting layout on yield of Turmeric under drip irrigation system (2015)

Turmeric planting on both sides of 75cm wide ridges at spacing of 37.5 X 30cm alongwith drip irrigation at 40% CPE at an alternate day is recommended for efficient water use and maximization of yield in medium black soils under Plain Zone of Maharashtra.

36. Standardization of fertigation in Turmeric (Curcuma longa L) (2015)

The application of 25 t ha^{-1} FYM and following fertigation schedule at 75% RDF (150:75:75, N:P_2O_5: K_2O Kg ha^{-1}, respectively) in the form of water soluble fertilizers through drip irrigation (scheduled at alternate day of 50 % CPE) is recommended for maximum turmeric yield and optimum soil fertility in medium black soils under Plain Zone of Maharashtra.

Fertigation Schedule for Turmeric

Sr. No.	Crop Stage	Duration after planting of Turmeric	Nutrients Applied (kg ha^{-1})			Nutrients Applied (kg per week)		
			N	P	K			
1	Planting to establishment	3rd to 4th week (2 equal splits)	15	15	7.5	7.500	7.500	**3.750**
2	Active vegetative stage	5th to 14th week (10 equal splits)	75	22.5	15	7.500	2.250	**1.500**
3	Rhizome initiation stage	15th to 26th week (12 equal splits)	37.5	22.5	22.5	3.125	1.875	**1.875**
4	Rhizome maturation stage	27th to 32nd week (6 equal splits)	22.5	15	30	3.750	2.500	**5.000**
	Total	30 week	150	75	75			

37. Deficit irrigation for onion (*Allium cepa L.*) by drip method. (2016)

Irrigation at 80 % ETc through drip irrigation at alternate day is recommended for maximum production of rabi onion on raised bed in medium deep black soils of Western Maharashtra.

38. Yield response of Marigold to different colour and shading percentage of shade nets (2016)

The plantation of marigold (August planting) at 65 × 30 cm spacing in red shade net house with 50% shading and daily drip irrigation at 85% ETr is recommended for higher yield, returns and water use efficiency.

39. Yield response of drip irrigated Cucumber to mulch and irrigation regimes under different shading nets. (2016)

The plantation of cucumber (February planting) in red shade net house with 50% shading and daily drip irrigation at 60% ETc with silver-black plastic mulch is recommended for higher yield, returns and water use efficiency.

40. Field evaluation of steady and unsteady drain spacing equations for clay soils (2016)

Van Schilfgaarde's (unsteady state) equation is recommended for optimal design of subsurface drainage system (for deciding spacing and depth of drain pipes) under waterlogged, heterogeneous and deep impervious layered Vertisols of Maharashtra.

41. Determination of surface drainage coefficient through rainfall analysis (2016)

The drainage coefficient (mm) values developed by Mahatma Phule Krishi Vidyapeeth are recommended for the design of surface drainage system for Tahsils of Nandurbar, Dhule, Jalgaon, Pune and Kolhapur districts. Further the maps developed in Geographical Information System (GIS) are recommended for estimating the drainage coefficient values.

42. Estimation of weekly reference evapotranspiration for irrigation scheduling over the Western Maharashtra. (2016)

Weekly average "reference evapotranspiration" developed by Mahatma Phule Krishi Vidyapeeth for Tahsils of Western Maharashtra are recommended for computation of water requirement of different crops. Further, the maps developed in Geographical Information System (GIS) are recommended for estimating the values of weekly average reference evapotranspiration at the specified location.

43. Estimation of weekly crop evapotranspiration (ETc) for effective irrigation scheduling in Sugarcane for the Western Maharashtra. (2016)

The tables developed by Mahatma Phule Krishi Vidyapeeth for Tahsils of Western Maharashtra are recommended for estimating weekly water and irrigation requirement of sugarcane (Adsali, preseasonal and suru) by surface and drip methods. Further, the maps developed in Geographical Information System (GIS) are recommended for estimating weekly water and irrigation requirement by surface and drip methods.

44. Estimation of weekly crop evapotranspiration (ETc) for effective irrigation scheduling in wheat crop for the Western Maharashtra. (2016)

The tables developed by Mahatma Phule Krishi Vidyapeeth for Tahsils of Western Maharashtra are recommended for estimating weekly water and irrigation requirement of wheat (normal, early and late sowing) by surface and sprinkler methods. Further, the maps developed in Geographical Information System (GIS) are recommended for estimating weekly water and irrigation requirement by surface and sprinkler methods.

45. Development of mobile application "Phule Jal" for estimation of reference evapotranspiration. (2016)

"Phule Jal" mobile app is recommended for estimation of reference evapotranspiration by different methods for deciding irrigation schedules.

46. Development of "Phule Irrigation Scheduler" software for scheduling of irrigation by surface, sprinkler and drip methods of irrigation. (2016)

"Phule Irrigation Scheduler" computer software is recommended for decision making support on irrigation water requirement and time of operation of surface, sprinkler and drip irrigation methods for different crops.

47. Development of mobile application "Phule Irrigation Scheduler" for scheduling of irrigation by surface, sprinkler and drip methods of irrigation (2016)

"Phule Irrigation Scheduler" mobile app is recommended for decision making support on irrigation water requirement and time of operation of surface, sprinkler and drip irrigation methods for different crops.

48. Development of web based application, "Phule Jal" for estimation of reference evapotranspiration (2017)

Web based **"Phule Jal"** developed by Mahatma Phule Krishi Vidyapeeth is recommended for estimation of reference evapotranspiration by different methods for deciding the irrigation scheduling.

49. Development of web based application, "Phule Irrigation Scheduler" for scheduling of irrigation by surface, sprinkler and drip methods of irrigation (2017)

Web based "**Phule Irrigation Scheduler**" developed by Mahatma Phule Krishi Vidyapeeth, is recommended for computing water requirement and time of operation of various irrigation systems during different plant growth stages of crops.

50. Estimation of weekly crop evapotranspiration (ETc) for effective irrigation scheduling in gram for the jurisdiction of MPKV, Rahuri (2017)

The tables developed by Mahatma Phule Krishi Vidyapeeth for Tahsils of Western Maharashtra are recommended for estimating weekly water and irrigation requirement of gram by surface and sprinkler methods. Further, the maps developed in Geographical Information System (GIS) are recommended for estimating weekly water and irrigation requirement at any specific locations by surface and sprinkler methods.

Estimation of weekly crop evapotranspiration (ETc) for effective irrigation scheduling in *Rabi* onion for the jurisdiction of MPKV, Rahuri (2017)

The tables developed by Mahatma Phule Krishi Vidyapeeth for Tahsils of Western Maharashtra are recommended for estimating weekly water and irrigation requirement of *Rabi* onion by surface and drip methods. Further, the maps developed in Geographical Information System (GIS) are recommended for estimating weekly water and irrigation requirement at any specific locations by surface and drip methods.

Estimation of weekly crop evapotranspiration (ETc) for effective irrigation scheduling in *Rabi* sorghum for the jurisdiction of MPKV, Rahuri (2017)

The tables developed by Mahatma Phule Krishi Vidyapeeth for Tahsils of Western Maharashtra are recommended for estimating weekly water and irrigation requirement of *Rabi* Sorghum by surface and drip methods. Further, the maps developed in Geographical Information System (GIS) are recommended for estimating weekly water and irrigation requirement at any specific locations by surface and drip methods.

Estimation of weekly crop evapotranspiration (ETc) for effective irrigation scheduling in soybean for the jurisdiction of MPKV, Rahuri (2017)

The tables developed by Mahatma Phule Krishi Vidyapeeth for Tahsils of Western Maharashtra are recommended for estimating weekly water and irrigation requirement of soybean by surface and drip methods. Further, the maps developed in Geographical Information System (GIS) are recommended for estimating weekly water and irrigation requirement at any specific locations by surface and drip methods.

51. Development of Decision Support System for Optimization of Farm Pond Size. (2017)

"Phule Farm Pond Water Budgeting" computer based decision support system is recommended for deciding the optimum size of farm pond and evaluating the existing farm pond size on the basis of water availability in catchment area and water demand in command area of the farm pond. This DSS can be used as a guideline.

52. Reference evapotranspiration under shading nets in semi-arid conditions (2017)

The equation based on reference evapotranspiration in open field developed by Mahatma Phule Krishi Vidyapeeth, Rahuri are recommended for estimation of reference evapotranspiration in shadnet houses. (Green-White 35%, 50%, 75% and Red 50%)

53. **Response of tomato to different shading percentages and irrigation levels under shadenet house condition (2017)**
    The green shadenet of 75% shading and daily drip irrigation of 75% of crop evapo-transpiration is recommended for higher yield, net income and B:C ratio for cultivation of indeterminate variety of tomato planted in November in shadnet house.
54. **Response of tomato to different irrigation and fertigation levels under polyhouse. (2017)**
    Daily drip irrigation of 95 % of crop evapo-transpiration and an alternate day fertigation with 125 % of recommended dose of water soluble fertilizers (i.e. 112.50:37.50:18.75 kg/ha upto flowering and 262.50:150.00:168.75 kg/ha after flowering $N:P_2O_5:K_2O$ respectively) is recommended for tomato cultivation in open ventilated polyhouse, for obtaining higher yield, net income and benefit : cost ratio of indeterminate variety planted in November.

55. **Response of tomato to synthetic colour mulches in conjunction with drip irrigation levels. (2017)**
    The white-black or silver-black plastic mulch (25 micron) with daily drip irrigation of 70 % crop evapotranspiration is recommended for open field cultivation of tomato indeterminate variety planted in January to obtain higher yield, net income and benefit : cost ratio.

56. **Response of broccoli under different colour shadenets with varying irrigation and fertigation regimes in *rabi* season (2018)**
    Cultivation of broccoli in *rabi* season under 50 % red shadenet house with irrigation at 90% crop evapotranspiration and fertigation at 80% RD (150:100:175 kg/ha N: $P_2O_5:K_2O$) through drip irrigation is recommended for obtaining higher yield and quality. However, 50% white shadenet house with irrigation at 90% crop evapotranspiration and fertigation at 80% RD (150:100:175 kg/ha N: $P_2O_5:K_2O$) through drip irrigation is recommended for higher net income and benefit:cost ratio.

57. **Muskmelon Response to Spectral Modification of Shading Nets under Different Drip Irrigation Regimes (2018)**
    Summer Muskmelon planting under red shade net house (50% shading) by using silver-black plastic mulch (40 micron thickness) and daily drip irrigation @ 120% of crop evapotranspiration is recommended for higher yield, productivity and water use efficiency in Maharashtra.

58. **Development of web and android based application for weather data input and retrieval system (WDIRS) for meteorological parameter (2018)**
    Mobile and web based application "Weather Data Input and Retrieval System (WDIRS)" developed by Mahatma Phule Krishi Vidyapeeth is recommended for weather data input and collection at central point and to use the weather data for estimation of reference evapotranspiration and other scientific purposes.

59. Estimation of weekly crop evapotranspiration (ETc) for effective irrigation scheduling in Safflower, Sweet corn, Cotton and Tomato crops for the jurisdiction of MPKV, Rahuri (2018)

The tables developed by Mahatma Phule Krishi Vidyapeeth for tahsils of Western Maharashtra are recommended for estimating weekly water and irrigation requirement of Safflower, Sweet corn, Cotton and Tomato crops by different irrigation methods. Further, the maps developed in Geographical Information System (GIS) are recommended for estimating weekly water and irrigation requirement at any specific locations by different irrigation methods.

60. Response of red cabbage to different irrigation and fertigation levels under polyhouse

Recommendation:

Cultivation of red cabbage (August transplanting) under naturally ventilated polyhouse with daily irrigation @ 90 % of crop evapotranspiration and soluble fertilizers @ 125 % of recommended dose (100:50:50 kg/ha N:P:K) through drip irrigation system at alternate day in 50 splits after 10 days of transplanting is recommended for obtaining higher yield, water use efficiency and monetary benefits.

61. Response of red cabbage to different irrigation and fertigation levels under varying shading percentage.

Recommendation:

Cultivation of red cabbage (August transplanting) under green-white shadenet house with 35% shade and daily application of irrigation @ 90% of crop evapotranspiration and water soluble fertilizers @ 100% of recommended dose (i.e. 80:40:40 kg/ha N:P:K) at alternate day in 48 splits after 10 days of transplanting through drip irrigation system is recommended for obtaining higher yield, water use efficiency and monetary benefit

62. Development of Crop Coefficients for Suru Sugarcane (Ratoon) for Rahuri region

Recommendation:

The crop coefficients given in the following table are recommended for the estimation of water requirement of Suru Sugarcane (Ratoon)

Week	Kc	Week	Kc	Week	Kc	Week	Kc
1	0.48	16	0.95	31	1.17	46	0.93
2	0.55	17	0.96	32	1.18	47	0.90
3	0.62	18	0.98	33	1.18	48	0.88
4	0.67	19	1.00	34	1.17	49	0.86
5	0.71	20	1.01	35	1.17	50	0.84
6	0.75	21	1.03	36	1.16	51	0.83
7	0.78	22	1.05	37	1.15	52	0.83
8	0.81	23	1.07	38	1.14		
9	0.83	24	1.08	39	1.12		
10	0.85	25	1.10	40	1.10		
11	0.87	26	1.12	41	1.07		
12	0.89	27	1.13	42	1.05		
13	0.90	28	1.14	43	1.02		
14	0.92	29	1.15	44	0.99		
15	0.93	30	1.16	45	0.96		

Alternatively following equation is recommended

Penman Monteith method:

$$Kc_t = 23.38\left(\frac{t}{T}\right)^5 - 59.18\left(\frac{t}{T}\right)^4 + 52.65\left(\frac{t}{T}\right)^3 - 21.23\left(\frac{t}{T}\right)^2 + 4.784\left(\frac{t}{T}\right) + 0.426$$

Where,

Kc_t is the crop coefficient of Suru Sugarcane (Ratoon) on t^{th} day; t is day and T is total crop growth period in day

63. Optimization of subsurface drain spacing and depth for sugarcane under waterlogged Vertisols

Recommendation:

The subsurface drainage system with 40 m drain spacing between two perforated pipes and 1.25 m drain depth is recommended for optimum drainage, improving soil health and economic production of sugarcane in waterlogged Vertisols.

64. Estimation of weekly crop evapotranspiration (ETc) for effective irrigation scheduling for Potato and Chilli within the jurisdiction of MPKV, Rahuri

Recommendation:

The tabular information and maps developed in Geographical Information System (GIS) by Mahatma Phule Krishi Vidyapeeth for tahsils of western Maharashtra are recommended for estimating weekly water and irrigation requirement of potato and chilli at specific location by surface and drip methods.

65. Deficit irrigation for rabi potato production under semi-arid conditions

Recommendation:

It is recommended to irrigate rabi potato with 100% irrigation at vegetative and tuber development stage and 20% less water than required during maturity stage (i.e. 60 days up to harvesting) for obtaining optimum production of potato.

66. Development of crop coefficient for rabi potato under semi-arid conditions

Recommendation:

The crop coefficients as per given in the following table are recommended for the estimation of water requirement of potato

Week since planting	Kc values
1	0.54
2	0.74
3	0.84
4	1.05
5	1.06
6	1.12
7	1.23
8	1.24
9	1.27
10	1.21
11	1.18
12	1.11
13	0.99

Alternatively following equation is recommended

$$Kc = 0.428\left(\frac{t}{T}\right)^5 - 0.002\left(\frac{t}{T}\right)^4 - 3.444\left(\frac{t}{T}\right)^3 + 1.763\left(\frac{t}{T}\right)^2 + 1.609\left(\frac{t}{T}\right) + 0.356$$

Where,

Kc_t = crop coefficient on t^{th} day

t = number of days since planting

T = total crop period

67. Development of yield response factor for *rabi* potato under semi-arid conditions

Recommendation :

It is recommended to use the following yield response factors for estimating the yield of potato for different irrigation strategies

1. The estimated seasonal crop response factor Ky for potato crop is determined as 1.54.
2. Stage wise yield response factor (Ky) are
   i. Vegetative stage (Ky_1) = 0.484
   ii. Tuber development stage (Ky_2) = 0.642
   iii. Maturity stage (Ky_3) = 0.410

68. Deficit irrigation for sugarcane under semi-arid conditions

Recommendation :

It is recommended to irrigate suru sugarcane with 100 % irrigation at tillering stage (45-135 days after planting), 30 % water deficit during grand growth stage (136 to 300 days after planting) and 60 % water deficit during maturity stage (301 to 360 days after planting) for obtaining optimum production in heavy deep black soils under scarcity zone conditions.

69. Development of crop coefficient for sugarcane under semi-arid conditions

Recommendation :

The crop coefficients given in the following table are recommended for estimation of water requirement of nursery planted seasonal (Suru) sugarcane.

Period (days after planting)	Crop coefficients (Kc)	Period (days after planting)	Crop coefficients (Kc)
0-40	0.40	201-210	1.29
41-50	0.31	211-220	1.29
51-60	0.43	221-230	1.28
61-70	0.53	231-240	1.27
71-80	0.63	241-250	1.25
81-90	0.73	251-260	1.22
91-100	0.81	261-270	1.19
101-110	0.89	271-280	1.15
111-120	0.96	281-290	1.10
121-130	1.03	291-300	1.04
131-140	1.08	301-310	0.98
141-150	1.13	311-320	0.91
151-160	1.18	321-330	0.83
161-170	1.21	331-340	0.75
171-180	1.24	341-350	0.66
181-190	1.26	351-360	0.56
191-200	1.28		

The following 2nd order polynomial function expressed as ratio of days after planting to total crop period (t/T) is recommended for estimating crop coefficient values (Kc) of nursery planted sugarcane grown under semiarid conditions.

$$Kc_t = -4.695\left(\frac{t}{T}\right)^2 + 5.566\left(\frac{t}{T}\right) - 0.360$$

Where,

Kc_t = crop coefficient on t^{th} day ;

t = number of days since planting ;

T = total crop period

Extension Activities:

Precision Farming Development Centre, Dept. of IDE, Dr. ASCAET, MPKV, Rahuri

State Level Workshop organized for Farmers, Govt. Officers, NGO's and Self help group etc.

Sr. No.	Workshop Title	Date	No. of Participants
1	National Workshop on "Technology Conversions for Precision Farming on Pomegranate"	14-15 Jan., 2010	124
2	State Level Workshop on "Precision Farming Technology for Flower Crops"	Jan 31- Feb. 1, 2014	375
3	National Workshop on "Protected Cultivation for Vegetable Crops"	March 10-11, 2015	404
4	State Level Workshop on "Water Conservation and Protected Cultivation Technologies	21 July, 2014	240
5	Protected Cultivation Farmers-Scientists Club	25 July, 2014	90
6	Vegetable Cultivation under Shadenet House : Production and Export	19 January, 2016	60
7	Workshop on "Crop Sequence and Marketing of Vegetables" for progressive farmers of Protected Cultivation Farmers-Scientists Club	18 May, 2017	25
8	State Level Workshop on "Polyhouse and Shednet house technical specification and Cost Norms"	12th Feb., 2019	25
9	State Level Workshop on "Implementation of Protected Cultiviation Guidelines"	02 March, 2019	150
	Total Numbers of Participants		**1493**

State Level Trainings Programme on Greenhouse and Micro Irrigation Technology Organized for Farmers, Govt. Officers, NGO's and Self help group etc.

Sr. No.	Year	No. of Trainings	No. of Beneficiaries
1.	1994-95	02	35
2.	1996-97	02	34
3.	1997-98	01	40
4.	1998-99	05	161
5.	1999-2000	01	53
6.	2000-01	03	115
7.	2001-02	05	188
8.	2003-04	03	132
9.	2004-05	03	139
10.	2005-06	07	257
11.	2006-07	12	411
12.	2007-08	19	456
13.	2008-09	19	388
14.	2009-10	20	575

15.	2010-11	22	513
16.	2011-12	19	502
17.	2012-13	25	777
18.	2013-14	18	613
19.	2014-15	12	523
20.	2015-16	11	546
21.	2016-17	04	173
22.	2017-18	03	81
	Total	217	6712

Skill Development Training Programme for Farmers for one month duration:

Sr. No.	Training Programme Title	Place of Training	Date	Number of Participants
1	Protected Cultivation Technologies for horticulture Crops	MPKV, Rahuri	15 Feb- 21 March, 2017	35
2	Greenhouse Operator	MPKV, Rahuri	05 February to 06 March, 2018	24
3.	Micro Irrigation Technician	MPKV, Rahuri	28 January, to 26 February, 2019	24
	Total Numbers of Participants			**83**

Glimpses of Skill development training programme on Greenhouse and Micro-irrigation technologies

Rashtriya Krishi Vikas Yojana project on "Irrigation Water Requirement Advisory Service"

State Level One dayWorkshop Organized for B. Sc. Agri/B.Tech. Agri. Engg. Students

Sr. No.	Workshop Title	Place	Date	No. of participants
1	One day workshop on "Phule Jal and Phule Irrigation Scheduler mobile application"	Shramshakti College of Agriculture Engineering & Technology, A/P-	1 Oct, 2018	144

		Maldad, Sangamner		
2	One day workshop on “Phule Jal and Phule Irrigation Scheduler mobile application”	College of Agriculture, Sonai	09 Oct, 2018	19
3	One day workshop on “Phule Jal and Phule Irrigation Scheduler mobile application”	College of Agriculture Engineering and Technology, Akola	05 Jan, 2019	04
4	One day workshop on “Phule Jal and Phule Irrigation Scheduler mobile application”	Precision Farming Development Centre, MPKV, Rahuri	01 Feb, 2019	39
5	One day workshop on “Phule Jal and Phule Irrigation Scheduler mobile application”	Shiv Shankar College of Agricultural Engineering, A/P-Mirajgaon	12 Feb, 2019	77
6	One day workshop on “Phule Jal and Phule Irrigation Scheduler mobile application”	Sahyadri College of Agricultural Engineering, A/P-Yeshwantnagar, Karad	15 Feb, 2019	37
7	One day workshop on “Phule Jal and Phule Irrigation Scheduler mobile application”	College of Agriculture, kolhapur	21 Feb, 2019	47
8	One day workshop on “Phule Jal and Phule Irrigation Scheduler mobile application”	Pad. Dr. D. Y. Patil College of Agricultural Engineering, Talsande, kolhapur,	22 Feb, 2019	113
9	One day workshop on “Phule Jal and Phule Irrigation Scheduler mobile application”	DMCA and DMCAET, Rajmachi, Karad	23 Feb, 2019	245
10	One day workshop on “Phule Jal and Phule Irrigation Scheduler mobile application”	Sampada Agri Polytechnic, TakaliDhokeshwar	02 Mar, 2019	50
11	One day workshop on “Phule Jal and Phule Irrigation Scheduler mobile application”	College of Agriculture, Dhule	11 Mar, 2019	129
12	One day workshop on “Phule Jal and Phule Irrigation Scheduler mobile application”	College of Agriculture, Nandurbar	12 Mar, 2019	59
13	One day workshop on “Phule Jal and Phule Irrigation Scheduler mobile application”	KVK , Nandurbar	12 Mar, 2019	18
14	One day workshop on “Phule Jal and Phule Irrigation Scheduler mobile application”	K.K. Wagh College of Agricultural Engineering and Technology, Nashik	13 Mar, 2019	90
15	One day workshop on “Phule Jal and Phule Irrigation Scheduler mobile application”	Shriram College of Agricultural Engineering, Paniv	04 Mar, 2019	49
	Total Numbers of Participants			**1120**


Glimpses of Workshop on
Phule Jal & Phule Irrigation Scheduler mobile applications

ICAR-IWMI Collaborative Ad-Hoc Research Project on "Enhancing Economic Water Productivity in Irrigation Canal Commands"

Workshop/Kisanmela organized for Farmers, Scientists and Govt. Officers etc.

Sr. No.	Workshop / *Kisanmela* Title	Place	Date	No. of Participants
1.	Workshop on "Water Productivity and Benchmarking"	Pride Hotel, University Road, Shivajinagar, Pune	9th April 2018	46
2.	*Kisanmela*	Sina Project Office,NimgaonGangarda.	14th February 2019	104
3.	Workshop on "Economic Water productivity and irrigation Benchmarking using OIBS/ SAMS tools"	The SheratonGrandpune.	7th June 2019	38
	Total Numbers of Participants			**188**

Word Bank Funded ICAR-NAHEP Project on " Centre for Advanced Agricultural Science and Technology (CAAST)for Climate Smart Agriculture and Water Management (CSAWM)"

Workshops/Training/Demonstration for Students, Scientist and VIP guests conducted under CAAST-CSAWM.

Sr. No.	Workshops/Training/Demonstration Title	Place	Date	No. of Participants
1	"Inception workshop" was organized at	Central Campus MPKV, Rahuri.	15th -17th July 2018	76
2	One day workshop organized on " Social Science Course Contents for PG Diploma"	College of Agriculture Pune,	28th August 2018	49

3	One-day workshop on "Application ofDrone Technology in Agriculture"	CAAST-CSAWM,Pune Sub-Campus,	28th February, 2019	150
4	One day Student – "Industry Interface on "Application of Drone technology in Agriculture"	MPKV, Rahuri	27th, March, 2019	375
5	One day Student – Industry Interface on "Robotics and Automation for Climate Smart Agriculture	MPKV, Rahuri	27th, March, 2019	250
6	Under NAHEP, the CAAST-CSAWM, Pune Sub-Campus, College of Agriculture Pune organized a guest lecture on "Application of Micro-Irrigation Technology in Crop Water Management "	College of AgriculturePune.	27th February,2019.	150
7	Stake Holder Workshop on Agro-Cliamtic Networking	Tasil – Akole, Dist. Ahmednagar	9th April,2019	100
8	Inauguration of NABARD sponsored "Automatic Weather Station"	ShenitTah. Akole, Dist. Ahmednagar	9th, April, 2019	100
9.	Two days workshop was organized on "Developing Village Level Contingency plans for Akole Block"	MPKV, Rahuri	20- 21th June, 2019	60
Trainings				
1.	Two days training programme was organized on "Python Programming in CSA",	MPKV, Rahuri	4-5th May, 2019	35
2.	Six days training programme was organized on "Application of precision farm machinery"	MPKV, Rahuri	22- 27th May, 2019	20
3.	Two days training programme was organized on "ICT for Effective Knowledge and Extension delivery for Climate Smart Agriculture and Water Management Technologies"	MPKV, Rahuri	11-12th June,2019	98
4.	Two days training programme was organized on " Hyper spectral remote sensing and spectroradiometery instruments : Role in climate smart agriculture development	MPKV, Rahuri	14-15th June, 2019	108
Demonstration				
1.	Organized demonstration on "Drone Spraying technology''	MPKV, Rahuri	29th May, 2019	55
	Total Numbers of Participants			1626

Demonstration of Drone Spraying Technology to VIP dignitaries by CAAST-CSAWM

Visit of VIP dignitaries to CAAST-CSAWM stall

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Firake N. N. 2013. Precision farming technologies for pomegranate crop. MPKV.Res. Pub.100/2013.

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Gadge S.B., A.A.Atre, V.N.Barai, Sustainable Agriculture through Natural Resource Management, The Institute of Engineers (India), ISBN 978-81-926207-2-5, 356.

Gorantiwar S.D., S.B.Gadge and . M.B.Gund, Revised Course Curriculum and syllabus with semester wise layout for B.Tech (Agril. Engineering) degree programme, MPKV,Rahuri, University publication,

Kadam, S.A., S.D.Gorantiwar and S. D. Dahiwalkar. 2015. Evapotranspiration for Estimation of Water Requirements. Mahatma Phule Krishi Vidyapeeth Publication No. MPKV/Res.Pub./164/2015 (109 pp)

Kadam, U.S., R.T. Thokal, S.D. Gorantiwar and A.G. Powar. 2008. Agricultural Drainage: Principles and Practices. Westville Pub., New Delhi, 350 pp. (ISBN 81-85873-35-0)

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Pampattiwar P.S., S.S.Magar, S.N.Suryawanshi, S.D.Dahiwalkar, S.D.Gorantiwar, Manual for course on drip and sprinkler irrigation methods, IWM Pub No.3 MPKV Rahuri, Aug. 1987.

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Meshram, D.T., S. D. Gorantiwar, Jaime da selva, V. T. Jadhav and Ramchandra. 2010. Water management in Pomegranate (Punica granatum L.). Fruit, Vegetable and Cereal Science and Biotechnology. 4(2):106-112.

Farmers-Scientist Club on Protected Cultivation:

PFDC, Rahuri has formed a club named as "Protected Cultivation Farmers-Scientists Club" in the Central Campus on July 25, 2014 in collaboration with Rahuri Tahsil Protected Cultivation Group under the guidance of Dr. T. A. More, Ex. Hon. Vice-Chancellor of MPKV, Rahuri and with the inspiration of Dr. K. D. Kokate, Director of Extension Education, MPKV Rahuri. Rahuri Tahsil Protected Cultivation Group in collaboration with MPKV, Rahuri exchanged ideas of advanced technology and accordingly educated the progressive farmers. This group includes progressive farmers, representatives of State Agriculture (DSAO, SDO, 8 and AO), eminent scientists from MPKV, Rahuri, Specialists from Krishi Vigyan Kendras, representatives of Regional Extension Centers and District Extension Centres.

Field visits of department Scientist to Farmers Field

Ad-hoc Projects (completed):

Sr. No.	Title	Funding Agency
1	Feasibility of solar photovoltaic pumping system for irrigation to vegetable crops	ICAR
2	Improvement of productivity of sugarcane under canal command of western Maharashtra in degraded soil water environment through drainage technology	ICAR
3	Characterization of groundwater pollution due to sugar factory	ICAR
4	Micro sprinkler irrigation for onion and garlic	ICAR
5	Remote sensing and GIS applications for improving productivity in Mula Command	ICAR
6	Land use/land cover dynamics and its impact on Godavari river basin	ISRO
7	Climate Change Knowledge Network in Indian Agriculture	GIZ, German Government
8	Enhancement of Groundwater Recharge through Open and Bore Wells	RKVY

Ad-hoc Projects (Ongoing):

Sr. No.	Title	Funding Agency
1	Precision Farming Development Centre	NCPAH MoAFW, GoI
2	"Centre for Advanced Agricultural Science and Technology (CAAST) for Climate Smart Agriculture and Water Management (CSAWM)"	ICAR-NAHEP
3	Irrigation Water Requirement Advisory Service (IWRAS)	RKVY
4	Canal water productivity and irrigation performance	ICAR-IWMI
5	Soil protection and rehabilitation for food security in India (Pro Soil)	GIZ, German Government

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