All India Coordinated Research Project on Agrometeorology

Annual Report 2013-14


Indian Council of Agricultural Research

Certificate

CHAUDHARY DEVI LAL OUTSTANDING ALL INDIA COORDINATED RESEARCH PROJECT AWARD-2013

(For All India Coordinated Research Project)

is presented to

All India Coordinated Research Project on Agrometeorology (CRIDA), Hyderabad

for outstanding work on climatic variability and development of real-time contingency plans

29 July, 2014
New Delhi

(S. Ayyappan)
Secretary (DARE) & Director General (ICAR)

(Radha Mohan Singh)
Minister of Agriculture, Govt. of India

Central Research Institute for Dryland Agriculture
(Indian Council of Agricultural Research)
Santoshnagar, Hyderabad - 500 059

CHAUDHARY DEVILAL OUTSTANDING ALL INDIA CO-ORDINATED RESEARCH PROJECT (AICRP) AWARD - 2013

Award 2013

The AICRP ON AGROMETEOROLOGY (AICRPAM) at CRIDA, Hyderabad has made significant progress in terms of climate characterization of majority of the states, bringing out several agro-climatic atlases, taking up frontier research on climatic variability, preparation of real-time contingency plans, issuing of Agromet advisories to farmers, networking of 100 automatic weather stations in KVKs and providing data support to weather based insurance products in several crops. Project Co-ordinating Unit at CRIDA, Hyderabad was selected as the best centre of the AICRP on Agrometeorology.

AICRP ON AGROMETEOROLOGY
CRIDA, Hyderabad
Andhra Pradesh

All India Coordinated Research Project on Agrometeorology

Annual Report - 2013-14

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Preface

India, predominantly an agriculture-based economy, is largely dependent on the monsoon. Weather continues to play a dominant role in agricultural production despite many technological advances made. Hailstorm incidence in early part of the 2014 and the recent HudHud cyclone has caused great damage to agriculture in India. Agrometeorological research and extension services assumes great significance in this era of climate change and ever-increasing extreme weather events.

In this background, the All India Coordinated Research Project on Agrometeorology (AICRPAM) is playing a significant role in identifying regions vulnerable to climate change, development of adaptation strategies and dissemination of micro-level agromet advisories. Along with this, AICRPAM is doing a commendable job in the manning of 100 Automatic Weather Stations in KVKs spread across the country to develop and disseminate the Agromet advisories at block level. It is also undertaking research on impacts of temperature and change in rainfall patterns on crops through modeling, designing contingency crop plans for different rainfall situations, development of weather insurance products, decision support systems for crop management and forewarning of pests and diseases through its Network Centers located in different agroclimatic zones of the country.

The efforts of the Co-operating Centers of AICRPAM in pursuing the assigned research programs are highly significant. Associated information to develop user friendly products and integrated approaches to assess meteorological hazards and extreme event impacts on agriculture and evaluation of potential risks that are useful for insurance organizations are highly desirable. Strong linkage among Research Institutes / SAUs engaged in managing dry lands is desirable to minimize the risks associated with weather variability for sustainable production. The Annual Progress report of 2013-14 contain results of research carried out during kharif 2013 and rabi 2013-14 across 25 centers in the country. I take this opportunity to congratulate the efforts made by the Agrometeorologists of all the centers and the Project Coordinator, Dr. VUM Rao and his staff at the Coordinating Unit in compilation of this valuable report. I believe that the results presented in the report will be useful for several ministries for policy implementation for minimizing the effect of weather aberrations.

(Ch. Srinivasa Rao)
Director

Acknowledgement

I wish to express my sincere gratitude to Indian Council of Agricultural Research for its continuous and generous help during the period under study. The encouragement and guidance from Hon'ble Director General and Secretary, DARE, Dr. S. Ayyappan; Deputy Director General (NRM), Dr. A.K. Sikka is gratefully acknowledged. The encouragement and guidance received from Dr. Ch. Srinivasa Rao, Director, CRIDA in the effective functioning of the Project and in preparation of this Annual Report is acknowledged with sincere thanks.

The untiring efforts made by the Agrometeorologists of all 25 Cooperating Centres in conducting the experiments as per technical program and in bringing out meaningful results made it possible to compile a comprehensive report. Help rendered by my colleagues, B. Bapuji Rao, M.A. Sarath Chandran, P. Vijaya Kumar and AVM Subba Rao in compiling the results of the reports is highly appreciated. My sincere appreciation to Shri IR Khandgonda in preparing necessary diagrams of the manuscript. The continuous support received from Shri A. Mallesh Yadav and Ms. Harini is acknowledged.

(V.U.M. Rao)
Project Co-ordinator (Ag. Met.)

1. Introduction

The All India Coordinated Research Project on Agrometeorology was initiated by ICAR in May 1983 with the establishment of Coordinating Cell at the Central Research Institute for Dryland Agriculture, Hyderabad and 12 Cooperating Centres at various State Agricultural Universities. After a detailed review and evaluation on the progress made by the project and realizing the importance of agrometeorological research support for enhancing food production, ICAR had extended the Cooperating Centres to the remaining 13 Agricultural Universities of the country w.e.f. April 1995. The network of 25 Agrometeorological Cooperating Centres are Akola, Anantapur, Anand, Bangalore, Bhubaneswar, Bijapur, Dapoli, Faizabad, Hisar, Jabalpur, Jorhat, Kanpur, Kovilpatti, Ludhiana, Mohanpur, Palampur, Parbhani, Raipur, Rakh Dhiansar (Chatha/Jammu), Ranchi, Ranichauri, Samastipur, Solapur, Thrissur and Udaipur. The Quinquennial Review Team has reviewed the research progress of the project in 1992, 1998-99, 2006 and recently in 2011.

1.1 Objectives

- To study the agricultural climate in relation to crop planning and assessment of crop production potentials in different agroclimatic regions
- To establish crop-weather relationships for all the major rainfed and irrigated crops in different agroclimatic regions
- To evaluate the different techniques of modification of crop micro-climate for improving the water use efficiency and productivity of the crops
- To study the influence of weather on the incidence and spread of pests and diseases of field crops

1.2 Technical Program

The Technical Program for the years 2012-14 for different centres of the project and a common core program decided for all the centres is given below with emphasis on location-specific research needs.

1) Agroclimatic Characterization (All centres)

- Development of database (Block, Tehsil or Mandal level) on climate and crop statistics (district level)

Agroclimatic Analysis

- Rainfall probability analysis
- Dry and wet spells
- Effective rainfall, water balance studies (FAO-CROPWAT) and harvestable rainwater for every week
- Characterization of onset of monsoon for crop planning
- Climatic and agricultural drought analysis
- Length of growing season and its variability
- Preparation of crop-weather calendars
- Consolidation of agroclimatic analysis in the form of Technical Reports and Agroclimatic Atlases
- Preparation of crop-wise manuals for weather-based decisions in crop management.
- Documentation of extreme events and their impacts on agriculture, including on livestock, poultry and fish (During the reporting year)

2) Crop-Weather Relationships (All Centres)

Centre	Kharif Crop(s)	Rabi Crop(s)
Akola	Soybean	Chickpea
Anand	Groundnut	Wheat
Anantapur	Groundnut	Chickpea (Nandyal)
Bangalore	Pigeonpea	Mango
Bijapur	Pigeonpea	Sunflower
Bhubaneswar	Rice	----
Chatha/Jammu	Maize	Wheat
Dapoli	Rice	Mango
Faizabad	Rice	Chickpea
Hisar	Clusterbean/Horticulture	Mustard, Wheat
Jabalpur	Soybean	Chickpea
Jorhat	Rice	Potato
Kanpur	Rice	Wheat
Kovilpatti	--	Blackgram, Greengram, Maize

Centre	Kharif Crop(s)	Rabi Crop(s)
Ludhiana	Rice	Wheat
Mohanpur	Rice	Potato
Palampur	Tea	Wheat
Parbhani	Cotton, Soybean	----
Raipur	Rice	Wheat
Ranchi	Rice	Wheat
Ranichauri	Finger millet	Wheat
Samastipur	Rice	Wheat, Winter Maize
Solapur	Pearlmillet	Sorghum, Chickpea
Thrissur	Coconut, Rice	Vegetables
Udaipur	Maize	Wheat

3) Crop Growth Modelling

Compilation of phenology for different crop species

Crop	Lead Centres	Associated Centre
Wheat	Ludhiana	Palampur, Anand, Jabalpur, Chatha/Jammu, Samastipur, Ranchi, Hisar, Kanpur, Ranichauri
Rice	CRIDA	Mohanpur, Samastipur, Dapoli, Faizabad, Thrissur, Bhubaneswar, Jorhat, Ranchi, Kanpur, Jabalpur, Raipur
Groundnut	Anand	Anantapur, Bangalore

4) Weather Effects on Pests and Diseases

Centre	Crop(s)	Pests/diseases
Anand	Mustard	Aphids
Anantapur	Groundnut	Leaf miner
Akola	Soybean	Spodoptera/Semilooper
Bangalore	Groundnut Redgram	late leaf spot HeliothisV
Bijapur	Grapes Pomegranate	Powdery mildew, Downy mildew Anthracnose, Bacterial Leaf Blight

Centre	Crop(s)	Pests/diseases
Bhubaneswar	Rice	Sheath Blight, Blast
Chatha/Jammu	Mustard	Aphids
Faizabad	Chickpea	Pod borer
Jabalpur	Chickpea	Heliothis
Kovilpatti	Cotton Blackgram	Aphids, Leaf hopper Powdery mildew
Ludhiana	Cotton	Sucking pests
Mohanpur	Mustard Potato	Aphids Late blight
Palampur	Mustard Wheat	Aphids Yellow rust
Parbhani	Cotton	Mealy bug, sucking pests
Ranchi	Rice	BLB, Stem borer, Blast
Ranichauri	Apple Amaranthus	Apple scab Leaf webber
Solapur	Sunflower	Leaf eating caterpillar (Heliothis)
Raipur	Rice Chickpea	Stemborer, Leaf blast Heliothis
Kanpur	Rice Wheat	Blight, Stem borer Blight
Thrissur	Rice	Stemborer, Leaf roller
Udaipur	Mustard	Aphids
Hisar	Mustard	Aphid

5) Agromet Advisory Services (All Centres)

- Monitoring of crop and weather situation, twice in a week and its updation on the website
- Development of contingency plans for aberrant weather situation
- Monitoring of extreme weather events and their impacts on farming systems on near real-time basis
- Value-addition to agromet information
- Economic impact assessment

2. Weather Conditions During The Year 2013

A brief account of rainfall with its onset, withdrawal and distribution during monsoon and post monsoon seasons of the year 2013 for the country as a whole as well as at 25 centres of AICRPAM is presented hereunder:

Onset of Southwest Monsoon (June – September):

Associated with the formation of Cyclonic Storm Mahasen (10th - 16th May) over southeast Bay of Bengal, low level cross equatorial monsoon flow strengthened over south Andaman Sea and adjoining south Bay of Bengal. This subsequently resulted in the advance of southwest monsoon over the Andaman Sea and some parts of the southeast Bay of Bengal on 17th May, 3 days before the normal date of 20th May. Cross equatorial flow over the Arabian Sea remained strong since the advance of southwest monsoon over the Andaman Sea.

The southwest monsoon set in over Kerala on 1st June, which is its normal date. The same day, monsoon advanced over the entire south Arabian Sea, Maldives-Comorin area, Lakshadweep, some parts of central Arabian Sea, entire Kerala, some parts of Coastal & South Interior Karnataka and most parts of Tamil Nadu. Convectively active phase of the Madden - Julian Oscillation (MJO) and the associated systematic northward propagation of the east-west shear zone at the mid-tropospheric levels during the subsequent period helped faster advance of monsoon and increased rainfall activity over the country.

The pace of advance of southwest monsoon this year had been the fastest during the period 1941-2013. Since onset took place over Kerala on 1st June, it rapidly covered the south peninsula and northeast India by 9th June and central, eastern parts and western Himalayan region by 15th June. This was also aided by formation and west- northwestward movement of a low pressure area along east-west trough during the same period. On 16th June, the presence of this low pressure area over east Rajasthan & neighbourhood superposed with a trough in mid & upper tropospheric westerlies provided conditions conducive for the large scale convection and wide spread monsoon rains over northwest India. This helped monsoon to advance over the entire country on 16th June, about a month earlier than its normal date of 15th July.

Rainfall distribution during monsoon season

The seasonal (June to September) rainfall received over the country as a whole and four broad geographical regions during the 2013 SW monsoon season are given in the table 2.1 along with respective long period average (LPA) values and deviations from normal.

Table 2.1 : IMD Sub-divisional rainfall during monsoon season (June – September) – 2013

S.No.	Centre	Actual	Normal	Excess or deficit (mm)	Deviation (%)
1	Andaman & Nicobar Islands	2152.1	1682.5	470	28
2	Arunachal Pradesh	1123.7	1768	-644	-36
3	Assam & Meghalaya	1185.7	1792.8	-607	-34
4	Naga., Mani., Mizo. & Tripura	973.8	1496.9	-523	-35
5	Sub-Himalayan W. Bl & Sikkim	1710.3	2006.2	-296	-15
6	Gangetic West Bengal	1159.9	1167.9	-8	-1
7	Orissa	1120.6	1149.9	-29	-3
8	Jharkhand	843.5	1091.9	-248	-23
9	Bihar	723.4	1027.6	-304	-30
10	East Uttar Pradesh	864.5	897.6	-33	-4
11	West Uttar Pradesh	758.6	769.4	-11	-1
12	Uttarakhand	1374.2	1229.1	145	12
13	Haryana, Chandigarh & Delhi	363.2	466.3	-103	-22
14	Punjab	480	491.9	-12	-2
15	Himachal Pradesh	775.2	825.3	-50	-6
16	Jammu & Kashmir	651.1	534.6	117	22
17	West Rajasthan	335.8	263.2	73	28
18	East Rajasthan	778.4	615.8	163	26
19	West Madhya Pradesh	1277.9	876.1	402	46
20	East Madhya Pradesh	1340.7	1051.2	290	28
21	Gujarat Region	1183.8	901	283	31
22	Saurashtra, Kutch & Diu	777.3	473.5	304	64
23	Konkan & Goa	3502.6	2914.3	588	20
24	Madhya Maharashtra	880.1	729.3	151	21
25	Marathwada	747.3	682.9	64	9
26	Vidarbha	1360.4	954.6	406	43
27	Chhattisgarh	1160.1	1147.3	13	1

S.No.	Centre	Actual	Normal	Excess or deficit (mm)	Deviation (%)
28	Coastal Andhra Pradesh	524.1	581.1	-57	-10
29	Telangana	949.7	755.2	195	26
30	Rayalaseema	420.3	398.3	22	6
31	Tamil Nadu & Pondicherry	321.6	317.2	4	1
32	Coastal Karnataka	3620.8	3083.8	537	17
33	North interior Karnataka	533.1	506	27	5
34	South interior Karnataka	826.6	660	167	25
35	Kerala	2562.5	2039.6	523	26
36	Lakshadweep	1057.2	998.5	59	6

The season rainfall from 1st June to 30th September 2013 was excess in 14 subdivisions, which constitutes 48% of the total area of the country, normal in 16 meteorological subdivisions (38% of the total area of the country) and deficient in 6 meteorological subdivisions (14% the total area of the country).

In June, except for 3 subdivisions from extreme northeast India (Arunachal Pradesh, Assam and Meghalaya, and Nagaland, Manipur Mizoram & Tripura), which received deficient rainfall, all the other subdivisions (33 out of 36) received excess (25 subdivisions) or normal (8 subdivisions) rainfall. In July, 10 subdivisions from northern, eastern and northeastern parts of the country and one in the extreme southeast (Tamil Nadu and Pondicherry) received deficient rainfall. Out of the 25 remaining subdivisions, 12 subdivisions received normal and 13 subdivisions, the majority of which are from central India and along the west coast, received excess rainfall. In August, rainfall activity weakened compared to the first two months, but was close to normal. During August, 8 subdivisions received excess rainfall, 18 subdivisions received normal rainfall and remaining 10 subdivisions received deficient rainfall. The excess subdivisions were Jammu & Kashmir, Punjab, west and east Rajasthan, west and east Madhya Pradesh, Gangetic West Bengal and Tamil Nadu. The deficient subdivisions were 3 of the 4 subdivisions of Maharashtra (except Vidarbha), north interior Karnataka, Lakshadweep, Orissa, Bihar, and 3 subdivisions from extreme northeast India.

In September, the rainfall activity reduced further and 17 subdivisions from north, east, northeast and central India received deficient or scantly rainfall. The 4 scantly subdivisions were Punjab, west and east Uttar Pradesh and east Madhya Pradesh. Out of the remaining 19 subdivisions, 9 subdivisions were in excess and 10 subdivisions were normal. The excess subdivisions were, west Rajasthan, 2 subdivisions of Gujarat, Madhya Maharashtra, 3 subdivisions of Karnataka, Kerala and Rayalaseema.

From the monthly distribution, it can be clearly seen that during most part of the season, the 3 subdivisions from the extreme northeast received deficient rainfall. On the other hand, most of the subdivisions from the central India and neighboring northwest India and south Peninsula received excess rainfall during the first 3 months of the season. However, no subdivisions experienced scanty rainfall during first 3 months of the season. Only in September, 4 subdivisions received scanty rainfall. Overall, there was a noticeable disparity in the spatial distribution of the rainfall with below normal or deficient rainfall over east and northeast India and above normal or excess rainfall over most of the other regions.

Floods and Droughts

Incessant rainfall associated with the monsoon low pressure systems and active monsoon conditions often caused flood situations over various states at different times of the season. The interaction between the monsoon low and the trough in the westerlies during the advance phase of monsoon caused severe floods during 16th–17th June over Uttarakhand. Downstream convergence of the stronger than normal low level winds during the first half of the season led to several events of incessant heavy rains and floods over Kerala. Towards the end of the season, Gujarat and adjoining areas of south Rajasthan experienced extremely heavy rainfall and flood situation due to the revival of the monsoon activity associated with a cyclonic circulation that remained quasi-stationary for a few days over Gujarat and neighboring areas. Apart from these, some other sub-divisions/states which experienced flood situations were Assam & Meghalaya, West Bengal & Sikkim, Odisha, Jharkhand, Bihar, Uttar Pradesh, Haryana, Himachal Pradesh, Madhya Pradesh, Gujarat, Vidarbha, Chhattisgarh, Andhra Pradesh and Karnataka. The floods occurred in Assam & Meghalaya, Jharkhand and Bihar were primarily due to the flooding of the rivers because of the heavy rainfall in the upper reaches of catchment areas.

During most part of the monsoon season, many districts of Arunachal Pradesh, Assam & Meghalaya, Nagaland-Manipur-Mizoram-Tripura, Jharkhand and Bihar experienced moderate to extreme drought conditions.

Withdrawal of southwest Monsoon

The weather over the western parts of Rajasthan remained mainly dry for more than a fortnight (from 27th August). A change over in the lower tropospheric circulation pattern over the region from cyclonic to anti cyclonic during 8th - 9th September resulted in the withdrawal of southwest monsoon from the region. Hence the withdrawal of southwest monsoon commenced from 9th September and the withdrawal line passed through Ganganagar, Bikaner and Barmer during 9th -18th September. The Southwest Monsoon withdrew from entire Jammu & Kashmir, Himachal Pradesh and Punjab; some parts of Haryana; some more parts of Rajasthan and some parts of Kutch on 19th and the withdrawal line passed through Kalpa, Hisar, Jodhpur and Naliya. However, an almost complete revival in the monsoon activity occurred from the 3rd week of September. With the successive formation of two low pressure areas and their westward movement across the central parts of the country caused the east-west trough to remain active contributing to above normal rainfall during this period. This development has stalled the further withdrawal of southwest monsoon.

Post-Monsoon (October- December) 2013

In the sub division wise Post- Monsoon (October – December) season rainfall, it is noticed that rainfall was excess in 16 sub-divisions, viz. Andaman & Nicobar Islands, Gangetic West Bengal, Odisha, Bihar, Jharkhand, East Uttar Pradesh, West Uttar Pradesh, West Rajasthan, West Madhya Pradesh, East Madhya Pradesh, Gujarat region, Saurashtra & Kutch, Chhattisgarh, Vidarbha, Telangana and Coastal Andhra Pradesh, normal rainfall in 6 sub-divisions, viz. Sub-Himalayan West Bengal & Sikkim, East Rajasthan, Konkan & Goa, Marathwada, Coastal Karnataka and Kerala and 13 sub-divisions viz., Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram, Tripura, Jammu & Kashmir, Himachal Pradesh, Haryana, Chandigarh & Delhi, Punjab, Madhya Maharashtra, Rayalaseema, North interior Karnataka, South Interior Karnataka, Tamil Nadu & Pondicherry and Lakshadweep, received deficit rainfall and scanty/no rain in one sub-division.

During the year, 14 out of 25 centers of the All India Coordinated Research Project on Agrometeorology, viz., Anand, Anantapur, Bhubaneswar, Bijapur, Chatha/Jammu, Dapoli, Hisar, Jabalpur, Ludhiana, Palampur, Parbhani, Ranichauri, Raipur and Udaipur received excess rainfall and remaining 12 centers received normal rainfall and remaining 11 centers received either deficit or scanty rainfall (Table 2.2).

Table 2.2 : Annual Rainfall received at AICRPAM centers during 2013

S.No.	Center	Actual	Normal	Departure (%)
1	Akola	729.3	813	-10
2	Anand	1375.0	853	61
3	Anantapur	573.0	432	33
4	Bangalore	847.5	917	-8
5	Bhubaneswar	1845.6	1548	19
6	Bijapur	771.6	594	30
7	Chatha/Jammu	1364.3	1124	21
8	Dapoli	4748.0	3529	35
9	Faizabad	1148	1001	15
10	Hisar	810.1	456	78
11	Jabalpur	2541.5	1395	82
12	Jorhat	1799.0	2148	-16
13	Kanpur	1234.1	8834	-86
14	Kovilpatti	421.3	723	-42
15	Ludhiana	896.0	733	22
16	Mohanpur	1426.2	1607	-11
17	Palampur	3142.0	2320	35
18	Parbhani	1216.1	963	26
19	Ranchi	1230.4	1399	-12
20	Ranichauri	1894.2	1270	49
21	Raipur	1619.0	1270	27
22	Samastipur	864.0	1235	-30
23	Solapur	666.9	721	-8
24	Thrissur	3225.3	2782	16
25	Udaipur	823.2	601	37

3. Agroclimatic Characterization

Characterization of crop growing environment is a pre-requisite in crop planning and evolving strategies to overcome climate /weather induced changes in the meso/micro climate. Anomalies in climatic variables need to be properly understood to make the agricultural sector resilient. Agroclimatic analysis is used to study the climatic characteristics and crop performance in a particular region and also to know the climatic variability/climate change and its impact on agriculture. Thus, historic data on climatic variables have to be analyzed using appropriate statistical tools enabling the development of location specific technologies/adaptive strategies. The analysis carried out by different centers on the agroclimatic characterization is reported hereunder:

Akola

Meteorological drought analysis was carried out using the Standardized Precipitation Index (SPI) for Western, Central and Eastern Vidarbha zones. Long term weather data (1901-2012) of district wise monthly rainfall series was used for computing the index. Three different time scales viz., 1 month SPI for the monsoon months (June, July, August, September), 3 month SPI (August and October) and 6- month SPI (November) were selected for monsoon and post monsoon periods. Mann-Kendall test was done to identify the trends in SPI and the results are given in Table 3.1.

Table 3.1: Mann Kendall Trend statistic of SPI for different time scales for the period 1901-2012

Vidarbha Zone	**SPI-1 June**	**SPI-1 July**	**SPI-1 Aug.**	**SPI-1 Sept.**	**SPI-3 Aug.**	**SPI-3 Oct.**	**SPI-6 Nov.**
Western	- 0.551 (NS)	-0.465 (NS)	+2.763 (Sig(0.01)	-0.878 (NS)	+1.044 (NS)	+1.710 (Sig(0.1)	+0.611 (NS)
Central	-1.157 (NS)	-1.157 (NS)	+1.081 (NS)	-1.368 (NS)	-0.397 (NS)	+0.415 (NS)	-0.873 (NS)
Eastern	-0.292 (NS)	-1.318 (NS)	+0.239 (NS)	-0.958 (NS)	-1.262 (NS)	-0.427 (NS)	-1.303 (NS)

In Western Vidarbha zone one-month SPI of August and three-months SPI of October showed a significant increasing trend, whereas one-month SPI of June, July and September tend to increase, though non-significant. In Central and eastern Vidarbha zones, SPI showed mostly non-significant decreasing trend for different time scales, reflecting increasing dryness , except the non- significant positive trend in SPI-3 October (Central zone) and SPI-1 August (Central and Eastern zone) indicating that August precipitation has increased in the last 112 years.

Anand

Trend analysis of climate change and its impact on maize cultivated in middle Gujarat agroclimatic zone of Godhra (Panchmahal district) was carried out. For climate change impact study, weather data for A2 scenario was derived from PRECIS downscaled model output prepared by IITM Pune at 0.4° resolution. Two periods of 30 years each, one for base line i.e., 1961-1990, and another for A2 projected scenario i.e., 2071-2100 (projected scenario) for Godhra was considered for climate change impact study. Linear regression and Theil-Sen approach was used to analyze the trends in temperature using long term data of Godhra station. The trend in temperature at Godhra for the period 1959-2009 is depicted in Table3.2. Maximum temperature time series at Godhra showed significantly increasing trend for winter (0.03 °C/year), monsoon (0.016 °C/year), post-monsoon (0.039 °C/year) and on an annual (0.027 °C/year) time scales. There are notable differences in slopes of linear regression and TS, but the trend was non-significant.

Table 3.2: Trend statistics and slopes of maximum temperature for Godhra

Parameter	Period/season	Thi-Sen analysis		Regression analysis	
		Slope	Kendall's tau	Slope	R^2
Maximum temp.	Winter	0.030	0.290	0.033	0.120
	Summer	0.017	0.110	0.043	0.110
	Monsoon	0.016c	0.169	0.019	0.070
	Post-monsoon	0.039a	0.310	0.049	0.220
	Annual	0.027a	0.350	0.033	0.240
Minimum temp.	Winter	0.017b	0.220	0.020	0.120
	Summer	0.027a	0.32	0.043	0.11
	Monsoon	0.017a	0.36	0.019	0.07
	Post-monsoon	0.025b	0.22	0.029	0.11
	Annual	0.024a	0.44	0.024	0.41
Rainfall		0.05	1.66	2.14	0.01

a: Significant at 99%, b :Significant at 95%, c: Significant at 90%

Bangalore

Rainfall probability analysis (Initial and conditional probabilities) was carried out using 39 years weekly rainfall data. A week that received rainfall of 10 mm or more is considered as a wet week.

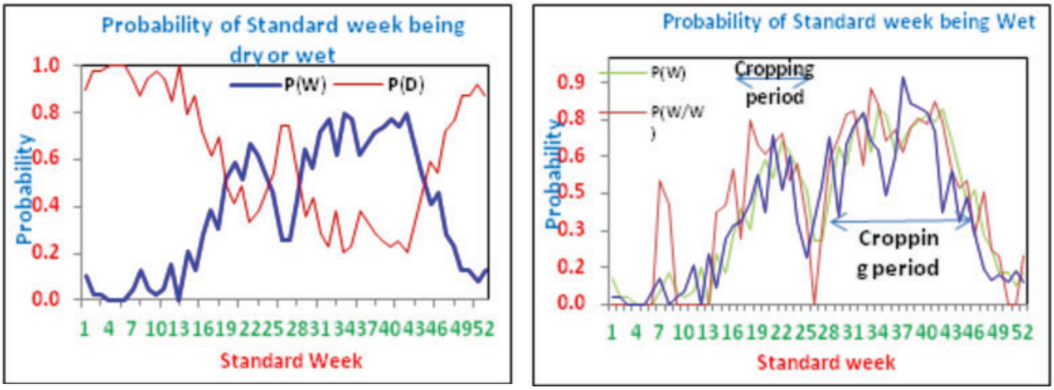


Fig. 3.1: Determining the crop growing period from probability analysis

Probability of wet week followed by wet week P(W/W) (more than 0.5) during 18th to 24th week of the pre monsoon season indicate that there exists higher chances of meeting crop water requirements during this period in most of the years (Fig. 3.1). This indicates that a short duration crop can be grown. As 28th to 45th week has continuous higher probability of wet week followed by wet week, it indicates that main crop of the year can be grown so that an adequate supply of moisture can be met if grown during this period in most of the years. Therefore, this period is identified as the crop growing period, i.e., the crop sown during 28th to 31st week would not suffer much from moisture stress. The crop sown during 29-31st week, may reach maximum growth or grand growth period during 38th to 44nd week, during which there will be generally highest water requirement. A higher probability value of P(W) (probability of wet week) and P(W/W) during this period indicate that there are higher chances of a given week being wet and even if previous week was dry. Hence the ideal crop growing period thus identified was between 28th to 44th weeks.

Climatic water balance at GKVK campus, Bangalore was worked out for the year 2013. It showed a runoff quantum of 221 mm (26%) out of the total 847 mm of rain received (Fig. 3.2)

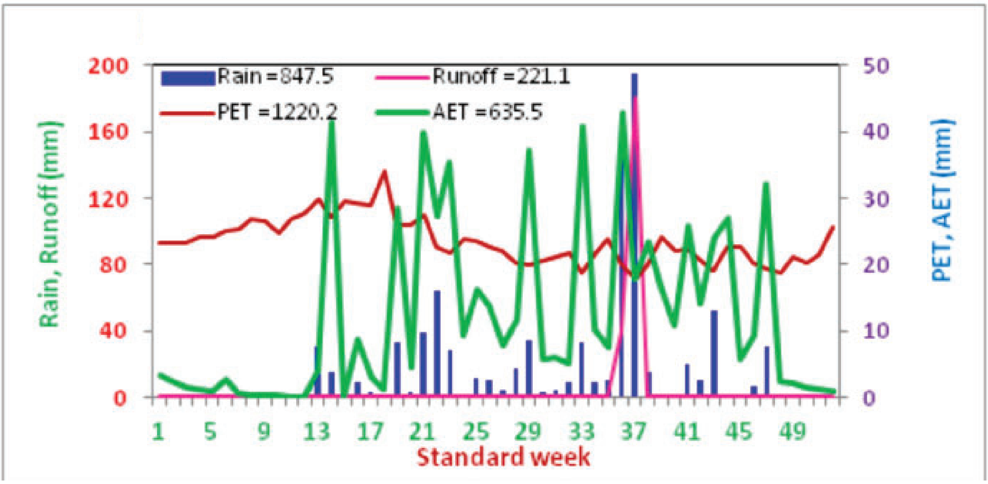


Fig. 3.2: Climatic water balance of GKVK soil (60 cm depth) during the year 2013

Bijapur

Meteorological drought climatology was antalyzed for Bijapur and Dharwad districts using weather data for the period 1961 to 2010. The analysis was carried out for three different time periods viz., 1961-90, 1991-2000 and 2001-2010.

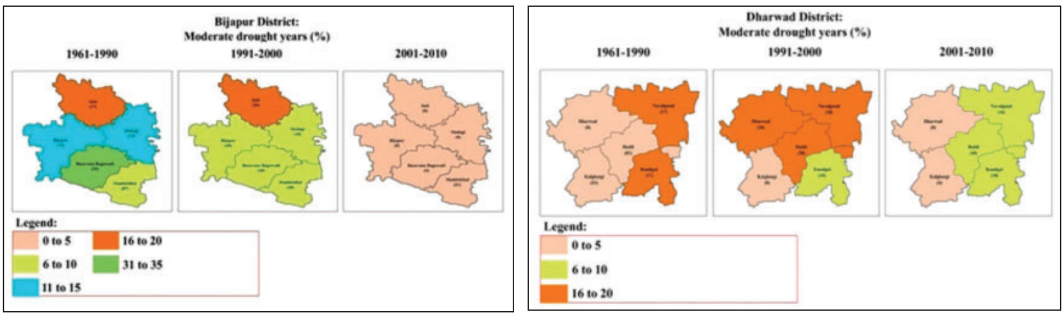


Fig. 3.3: Changes in moderate drought years in Bijapur and Dharwad districts during three time periods

The incidence of moderate drought years was more during the period 1961-90 in Bijapur district, and was more or less constant in the other two phases in both districts (Fig. 3.3). The incidence of severe drought year percentages was generally meager in both districts, except during 2001-2010 in Dharwad district.

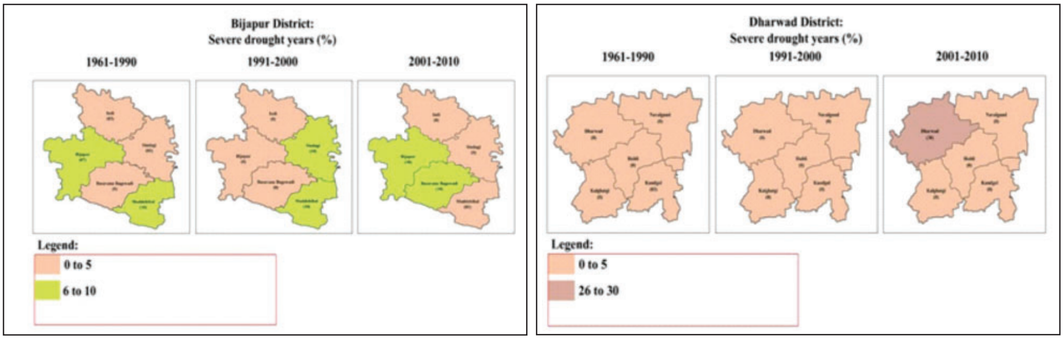


Fig. 3.4: Taluka-wise severe drought years (per cent) in Bijaur and Dharwas districts

Thus the two districts have shown diverse climatic variability in the three time periods at the micro-level (Fig 3.4) and need intensive understanding for development of crop planning in the region.

Jammu

The long term rainfall data of different time periods recorded at Jammu, Katra, Bhadarwah, Banihal Batote and Rajouri locations was utilized to estimate the frequency of occurrence of meteorological droughts of different intensities and the result of the analysis is presented in Table 3.3.

Table 3.3: Meteorological droughts of different intensities at different locations in Jammu region

Drought conditions	Jammu (1982-13)		Katra (1980-13)		Bhaderwah (1978-13)		Banihal (1972-13)		Batote (1977-13)		Rajouri (1994-13)	
	No. of years	Percentage	No. of years	Percentage	No. of years	Percentage	No. of years	Percentage	No. of years	Percentage	No. of years	Percentage
Drought free	15	47	18	53	18	50	19	45	22	59	10	50
Mild Drought (0-25% deficit rainfall)	12	38	14	41	15	42	21	50	10	27	9	45
Moderate Drought (26-50% deficit rainfall)	5	16	2	6	3	8	2	5	5	14	1	5
Sever Drought (> 50% deficit rainfall)	0	0	0	0	0	0	0	0	0	0	0	0
Total	32	100	34	100	36	100	42	100	37	100	20	100

Among these locations, Batote witnessed the highest percentage of drought-free years (59%) followed by Katra (53%), Bhadarwah (50%), Rajouri (50%), Jammu (47%) and Banihal (45). Almost 50% of the years experienced mild drought situations (0-25% deficit rainfall) at Banihal; while the highest percentage (16%) for moderate drought years (26-50% deficit rainfall) was recorded at Jammu. None of these six locations falling under different agroclimatic zones of Jammu province suffered from severe drought (> 50% deficit rainfall) in any of the years under study.

Jorhat

Extreme weather event analysis was performed for Upper Brahmaputra Valley Agroclimatic Zone (UBVZ) of Assam using 'RClimdex 1.1'. Rainfall data from 1981 to 2010 (30 yrs) except for Jorhat (1972-2010, 40 yrs.) was used for the study.

Table 3.4: District wise magnitude of change (slope) & trend in extreme events of different weather parameters for UBVZ, Assam

Parameter	Unit	District wise slope & trend				
		Golaghat	Sivasagar	Tinsukia	Jorhat	Dibrugarh
R_x1day	mm	-0.107	-0.030	-0.379	-0.341	0.188
R_x5day	mm	-1.323	-1.410	-0.905	-0.706	0.602
SDII	mm/ day	0.016	-0.233	-0.008	-0.045	0.011
R10mm	days	-0.227	-0.803	0.080	-0.190	0.003
R20mm	days	-0.099	-0.526	0.046	-0.217	-0.143
R75mm	days	-0.018	-0.052	-0.021	-0.019	0.050
CDD	days	0.869	0.567	0.541	0.270	0.485
CWD	days	-0.055	-0.051	0.065	-0.067	-0.129
R95p	mm	-0.753	-9.314	-4.724	-1.982	-1.249
R99p	mm	-2.903	-2.168	-0.762	-1.996	0.899
PRCPTOT	mm	-6.413	-27.888	-0.352	-7.342	-3.838

[RX1day- Monthly maximum 1-day precipitation; Rx5day- Monthly maximum consecutive 5-day precipitation; SDII- Annual total precipitation divided by the number of wet days (defined as PRCP>=1.0mm) in the year; R10mm- Annual count of days when PRCP>=10mm; R20mm- Annual count of days when PRCP>=20mm; R75mm- Annual count of days when PRCP>=75 mm, nn is user defined threshold; CDD- Maximum number of consecutive days with RR<1mm; CWD- Maximum number of consecutive days with RR>=1mm; R95p- Annual total PRCP when RR>95th percentile; R99p- Annual total PRCP when RR>99th percentile; PRCPTOT- Annual total PRCP in wet days (RR>=1mm)]

The slope of the parameters indicate the magnitude of change over time and the positive or negative sign indicates the direction of the change (Table 3.4). Monthly maximum 1-day (R_X1day) and 5-day (R_X5day) precipitation shows positive trend only in case of Dibrugarh district. Similar is the case with 'annual count of days when PRCP>=10mm' (R10mm) and 'annual count of days when PRCP>=75mm' (R75mm). At the same time CWD for Dibrugarh showed a negative trend. This indicates that the Dibrugarh is experiencing more intense rainfall events, where as its number of rainy days are decreasing during the last 30 years. The only district which showed a slight positive trend of CWD (0.065) is Tinsukia, but it may become negative in near future as the CDD has a higher positive value of 0.541. Tinsukia is also maintaining a positive trend for low intensity rainfall events (R10mm and R20mm). Overall, Dibrugarh and Tinsukia are better placed than other three districts with respect to the rainfall status in Upper Brahmaputra Valley Agroclimatic Zone of Assam.

Kovilpatti

Length of growing period (LGP) analysis was carried out for the Southern agroclimatic zone of Tamil Nadu. The length of growing period ranged from 7 to 45 weeks with an average of 12.53 weeks. Lower growing period of 7 weeks was noticed in Ottapidaram whereas higher growing period of 45 was observed with Shenkottai. The spatial distribution of LGP in the southern agroclimatic zone in depicted in Fig. 3.5.

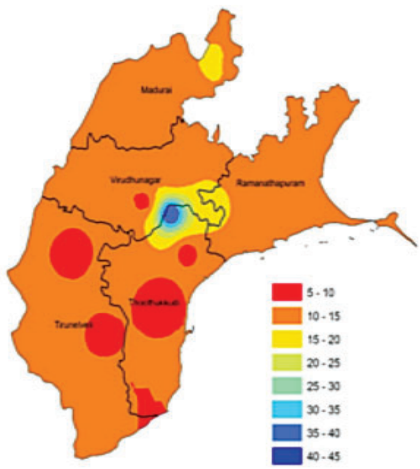


Fig. 3.5: Spatial distribution of LGP (weeks) in the Southern agroclimatic zone of Tamil Nadu

Palampur

Weather data for the period 1985-2013 was analyzed to detect any trend in the occurrence of hail events and dew days. number of hail events (since 1990) and dew days (since 1985) are increasing. Number of days with snow fall also was found to be on the rising side.

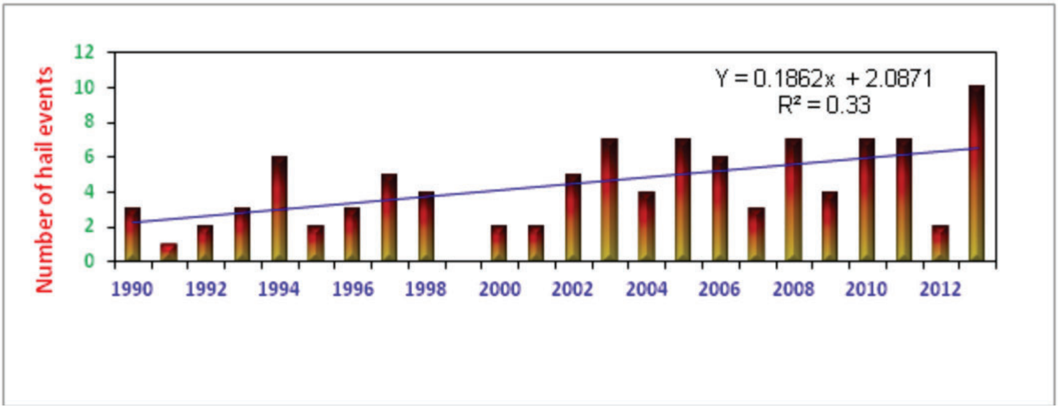


Fig. 3.6: Variations in occurrence of hail events at Palampur

It was noticed that both the extreme weather events are on rise. Hail events were found to be increasing at the rate of 0.18 per year (Fig. 3.6) and dew days at the rate of 3 per year (Fig. 3.7). However, the trends in the occurrence of snow events are not consistent (Fig. 3.8) and these are linked to meso-scale phenomenon like Western Disturbances.

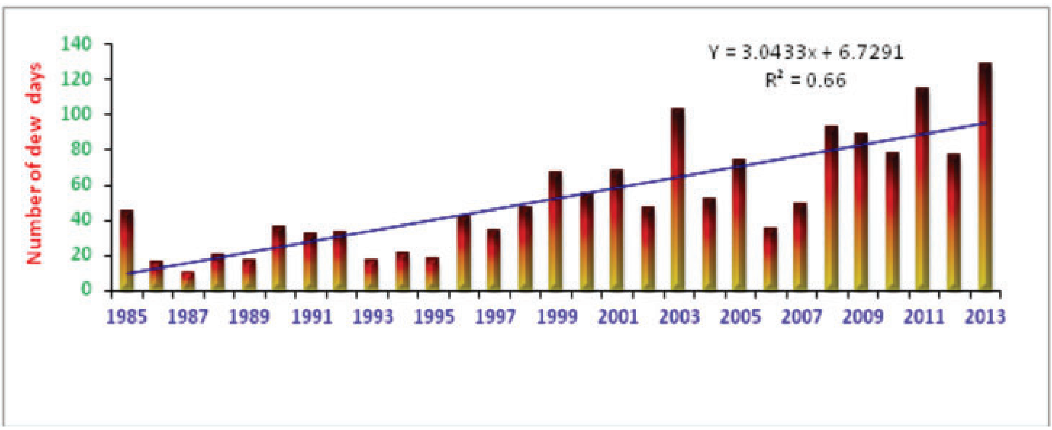


Fig. 3.7: Variations in occurrence of dew days at Palampur

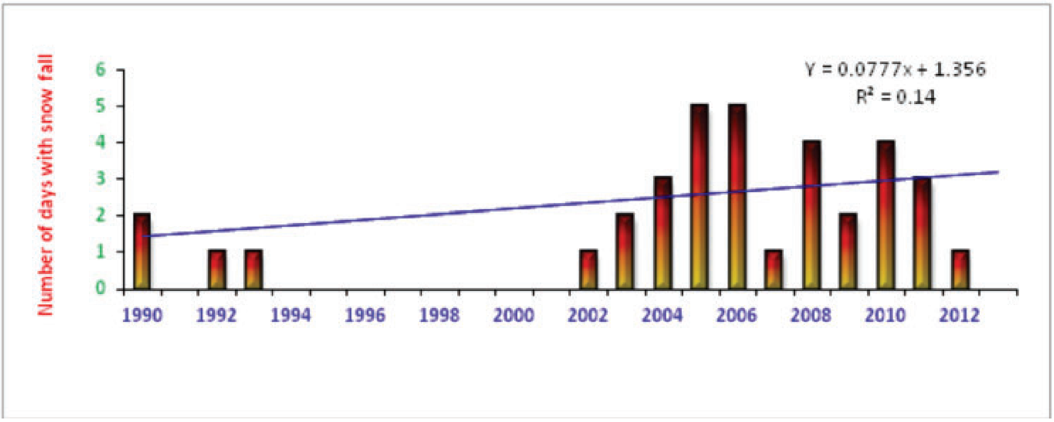


Fig. 3.8: Variations in occurrence of snow events at Palampur

Raipur

Changes in quantum of rainfall received on seasonal and annual basis in recent years 1991-2013 was compared against the base period (1961-1990) and the spatial distribution of changes, expressed in percentage are presented in Fig. 3.9.

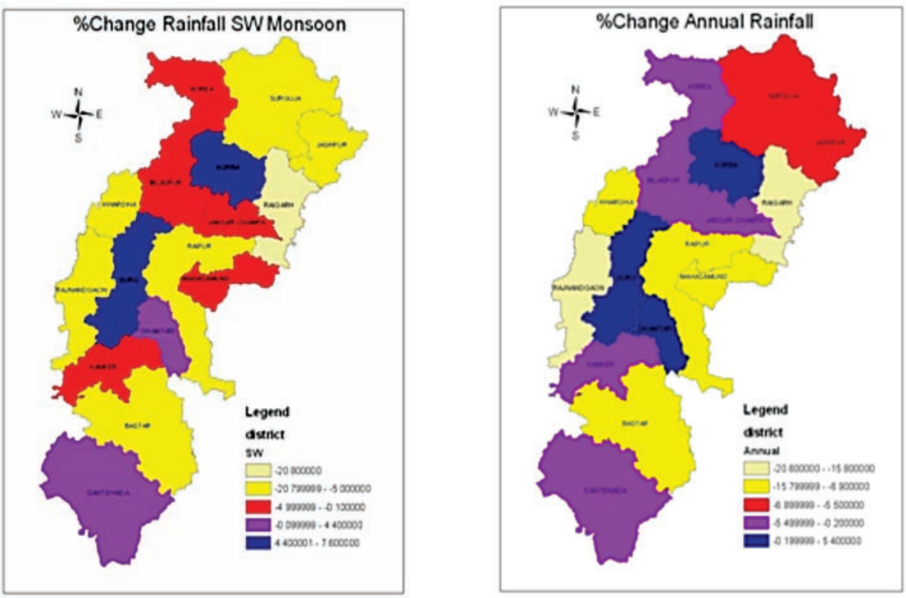


Fig. 3.9: Rainfall departures (Percentage) during 1991-2013 as compared to the base period 1961-90 for Southwest monsoon as well as annual periods.

It can be observed that in most of the districts, there was a negative departure of SW rainfall and it varied from -0.1 per cent to -20.8 per cent. Rainfall qunatity has decreased in recent times by about 20.8 per cent in Raigarh and by about 11.4 per cent in Rajnandgaon. A decreasing trend in annual and SWM rainfall was observed in Ambikapur and there is a rising trend in annual rainfall for Mahasamund. Raigarh and Rajnandgaon districts showed maximum reduction (15-20%) in annual rainfall during 1991-2013.

Samastipur

Weekly water balance was estimated for a period of 33 years (1980-2012) for three locations in Darbhanga, Hayaghat and Jale districts, using the Thornthwaite and Mather method (1955). LGP was estimated based on Moisture Adequacy Index (MAI). Since the study area falls under sub humid climatic condition, the onset of growing season has been considered at a week when MAI is greater than or equal to 0.75, which is considered as the minimum moisture level for starting the sowing of crops like rainfed rice, maize, pigeonpea and sunflower. The termination of growing period was considered at a week from where MAI is less than 0.33. From the results of water balance, LGP of each individual year during the period from 1980 to 2012 was determined for the areas having course, medium and fine textured soils. LGP variability analysis revealed that growing period is showing a decreasing trend in all types of soils in the district (Fig. 3.10). The rate of decrease in LGP in course textured soil was almost a day per year during the study period. The lowest rate of decrease in LGP was recorded in fine textured soil perhaps due to higher organic matter content and fine pores.

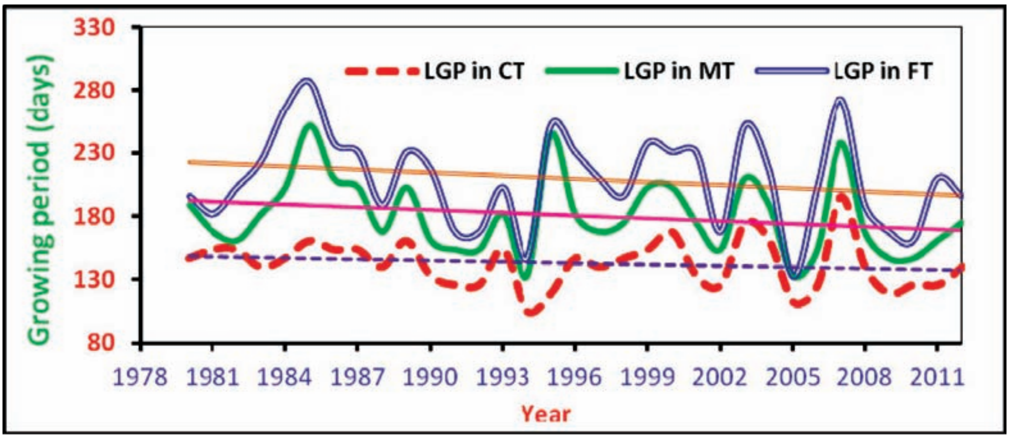


Fig. 3.10: Variations in LGP in course textured (CT), medium textured (MT) and fine textured (FT) soils in Darbhanga district

LGP was estimated based on soil moisture index (SMI) also. For the crops grown under sub humid condition, the onset of growing season has been considered in a week when SMI ≥ 0.70 (Victor and Sastry, 1984) and it ends when SMI<0.40 (Hargreaves, 1984). The mean LGP in course textured soil was 114±18 days, 129±22.5 days in medium textured soil and 143±29.5 days in fine textured soil. The water availability period was also estimated for coarse, medium and fine textured soils based on actual ET, 0.25 PET and 0.5 PET. The period during which AET remains above 0.5 PET was during 23 to 43 standard meteorological week (SMW) and 0.25 PET during 17 to 45 SMW (Fig. 3.11).

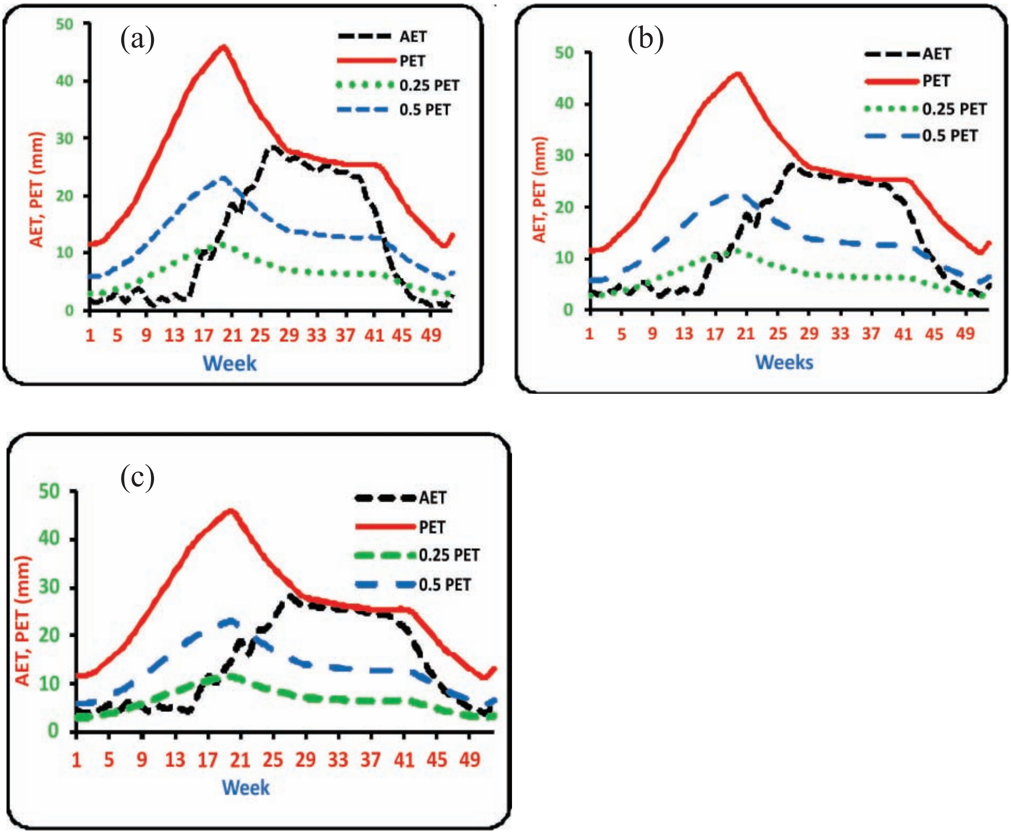


Fig. 3.11: Water availability period in coarse (a), medium (b) and fine textured (c) soils in Darbhanga district of Bihar

For medium textured soil, during 23 to 45 SMW, AET remained above 0.5 PET and from 17 to 51 SMW above 0.25 PET (Fig. 6). AET remained above 0.5 PET during 23 to 46 SMW in fine textured soil and 17 to beyond 52 weeks above 0.25 PET (Fig. 3.11).

Solapur

The seasonality index was computed for all the districts of Maharashtra for two different periods viz. the first 50 year 1901-1950 and the later 50 year period 1951-2000. The lower seasonality index value indicates better distribution of monthly rainfall among the months of the year. The spatial distribution of seasonality index remained almost same in both the periods. The value of seasonality index was low at Sangli and Solapur and was in the range 0.8-0.9 (Fig. 3.12). This indicates that only in these two districts, rainfall was purely seasonal and was evenly distributed in four months though the mean monsoon rainfall was less compared to other districts of Western Maharashtra. An increasing trend in seasonality index is thus an indicator of alarming situation for the agriculture. To identify the changes in the seasonality index, the differences in the seasonality index was computed (table 3.5). The seasonality index has increased in all the districts except Satara. Trend analysis of SI was done to check its significance. Significant increasing trends (95%) in Pune districts and in for the districts of Nandurbar, Dhule, Jalgaon, Nasik, Ahmednagar, Solapur, Satara, Sangli, Kolhapur, Significant decreasing trend (95%) which is a good indicator increased in even distribution in the monthly scale was noticed in Nasik .

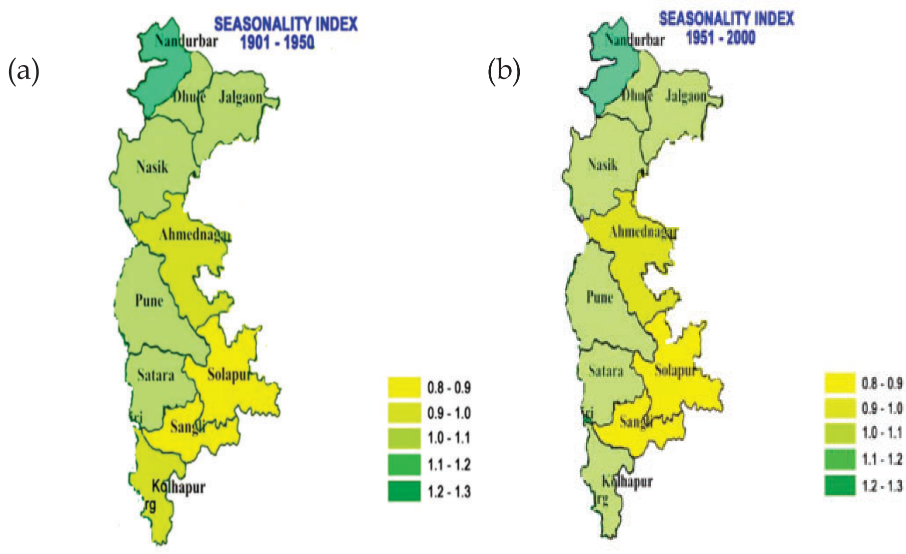


Fig. 3.12: Values of the Seasonality Index (SI) of the districts of Western Maharashtra during the period (a) 1901-50 and (b) 1951-2000.

Table 3.5 : Trends in Seasonality Index (SI) of the districts of Maharashtra during the period 1901-50 and their magnitude.

S.N	Districts	SI 1901 -50	SI 1951 - 2000	Difference in Seasonality index	Trend in Seasonality index
1	Ahmednagar	0.9-1.0	0.9-1.0	Negative Seasonality index (- S .I.)	P.T
2	Dhule	1.0-1.1	1.0-1.1	Negative Seasonality index (- S .I.)	P.T
3	Jalgaon	1.0-1.1	1.0-1.1	Negative Seasonality index (- S .I.)	P.T
4	Kolhapur	0.9-1.0	1.0-1.1	Negative Seasonality index (- S .I.)	P.T
5	Nandurbar	1.1-1.2	1.1-1.2	Negative Seasonality index (- S .I.)	P.T
6	Nasik	1.0-1.1	1.0-1.1	Negative Seasonality index (- S .I.)	P.T
7	Pune	1.0-1.1	1.0-1.1	Negative Seasonality index (- S .I.)	P.T (95 %)
8	Sangli	0.8-0.9	0.8-0.9	Negative Seasonality index (- S .I.)	P.T
9	Satara	1.0-1.1	1.0-1.1	Positive Seasonality index (+ S I)	P.T
10	Solapur	0.8-0.9	0.8-0.9	Negative Seasonality index (- S .I.)	P.T

P.T. – positive trend ; N.T – negative trend.

Spatial analysis of trends in monthly total rainfall and trends in seasonality index will help the planners in identifying the zones in Western Maharashtra to augment in the best management of water resources for all the sectors.

4. Crop-Weather Relationships

Many physiological processes in the crop plants are governed by the microenvironment in which they grow. All crop growth models (dynamic / mechanistic /deterministic) are inadvertently use relations between crop growth and weather elements. A better understanding of these relationships enable scientists to estimate location specific or regional crop yields in advance. The information also helps in the development of genotypes / production systems and in the designing of management strategies both during growing season and post-harvest. The results of the research carried out under crop-weather relationships program at different centers are discussed hereunder:

Kharif 2013

Rice

Dapoli

Crop-weather relationship was studied in nine varieties sown on three dates [23, 24 and 25 Standard Meteorological Weeks (SMW)]. Growing degree days were calculated for six phenophases of all the varieties (Fig. 4.1). Among the varieties, Karjat-2 and Swarna recorded highest accumulated GDD of 2231, 2206, 2199, when sown on 23rd, 24th and 25th SMW, respectively.

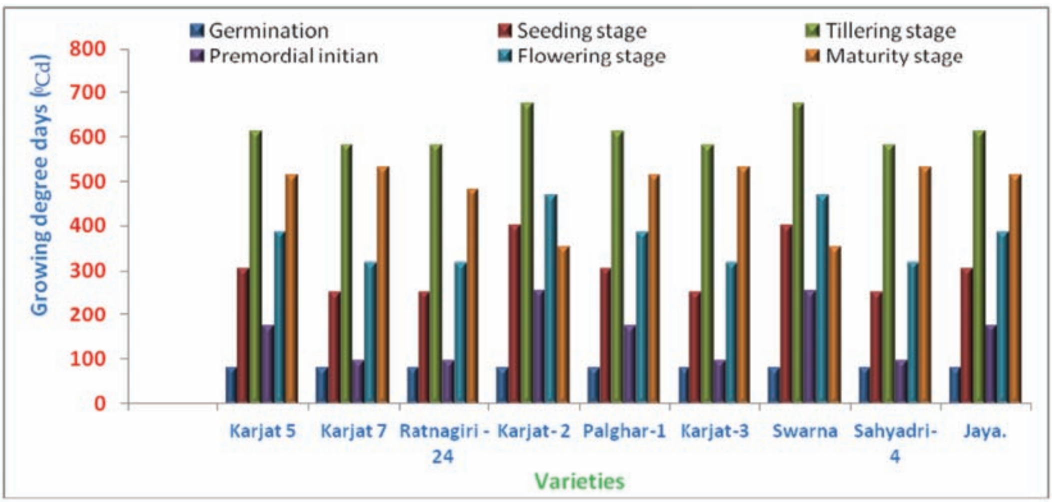


Fig. 4.1: GDD accumulated by different rice varieties during different phenophases when sown on 23 SMW.

Thermal requirements were also worked out in terms of Heliothermal unit (HTU). Among different varieties, Karjat-2 and Swarna recorded highest HTU of 6818, 7329, 8118, when sown on 23, 24 and 25 SMW, respectively (Fig. 4.2).

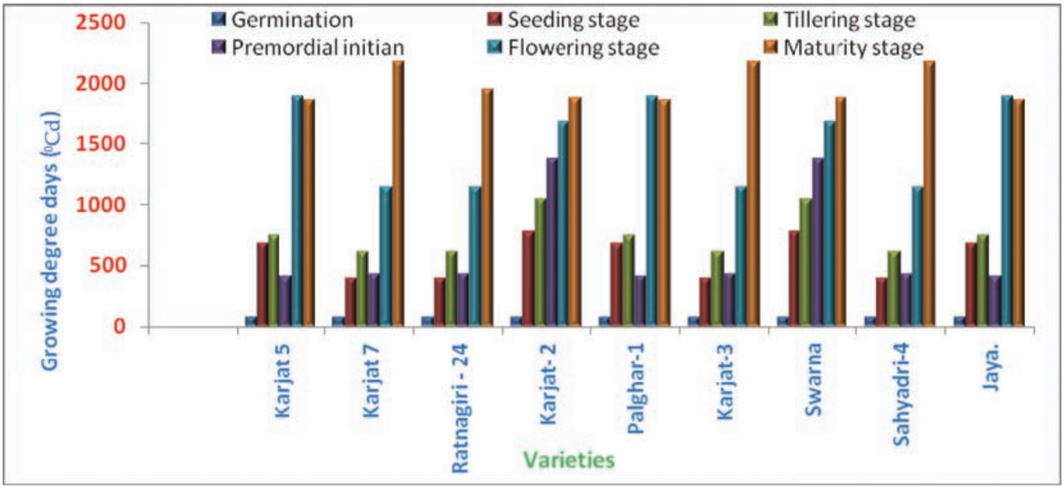


Fig. 4.2: HTU accumulated in different rice varieties during different phenophases when sown on 23 SMW.

Faizabad

Radiation use efficiency of three rice cultivars (Sarjoo-52, NDR-359 and Swarna), sown on three different sowing dates (5, 15 and 25 July 2013) was deduced (Table 4.1).

Table 4.1: Radiation Use Efficiency (g/MJ) of rice as affected by various treatments

	DAT						
Treatments	**15**	**30**	**45**	**60**	**75**	**90**	**Harvest**
Date of transplanting							
July 5	1.1	2.2	2.8	2.4	2.8	2.9	2.6
July 15	1.4	1.5	2.2	2.4	2.6	2.7	2.3
July 25	1.2	1.5	2.2	2.1	2.3	2.1	2.2
Varieties							
Sarjoo-52	1.8	1.8	2.2	2.6	2.5	2.8	2.4
NDR 359	1.4	1.8	2.1	2.4	2.3	2.4	2.3
Swarna	1.3	1.5	2.1	2.4	2.3	2.3	2.3

Highest RUE was recorded for crop sown on July 5, followed by crop sown on July 15 and 25. Among varieties, Sarjoo-52 showed highest RUE at all stages of crop growth, followed by NDR 359. RUE increased up to 90 days after transplanting and thereafter decreased.

Raipur

Effect of sowing time on relative growth rate (RGR) of three promising varieties was assessed. Relative growth rate is an index of the amount of growing materials per unit dry weight of plant per unit time.

Table 4.2: Relative growth rate g/hill/day in rice cultivars as affected by different dates of sowing.

Treatments	Relative growth rate (g/hill/day)						
Dates of sowing	**0-15 DAT**	**16-30 DAT**	**31-45 DAT**	**46-60 DAT**	**61-75 DAT**	**76-90 DAT**	**91-MATURITY**
15 June	0.037	0.050	0.042	0.059	0.023	0.012	0.002
25 June	0.047	0.042	0.068	0.032	0.023	0.013	0.002
05 July	0.026	0.050	0.051	0.058	0.026	0.010	0.002
SEm ±	**0.002**	**0.003**	**0.004**	**0.002**	**0.002**	**0.001**	**0.000**
CD (p=0.05)	**0.008**	**N/S**	**0.017**	**0.007**	**N/S**	**N/S**	**N/S**
Varieties							
Karma Mahsuri	0.032	0.052	0.056	0.052	0.020	0.015	0.001
MTU1010	0.034	0.052	0.056	0.048	0.024	0.011	0.001
Mahamaya	0.042	0.049	0.049	0.051	0.024	0.014	0.001
(Swarna 100:60:40)	0.042	0.044	0.051	0.046	0.024	0.010	0.004
(Swarna 60:40:40)	0.035	0.040	0.055	0.050	0.027	0.008	0.003
SEm ±	**0.002**	**0.004**	**0.005**	**0.002**	**0.002**	**0.001**	**0.000**
CD(p=0.05)	**0.007**	**N/S**	**N/S**	**N/S**	**N/S**	**0.004**	**0.001**

DAT: Days After Transplanting, NS – Non-significant

The crop sown on June 25 recorded highest relative growth rate (Table 4.2). For the June 25th sown crop, maximum RGR (0.068 g/g/day) was recorded during 31-45 DAT. In 15th June sowing, the RGR was at its highest (0.059 g/g/day) between 46-60 DAT. In 5th July sowing, the RGR showed fluctuating trend during different growth stages; RGR being maximum (0.058 g/g/day) between 46-60 days after transplanting.

Ranchi

FAO water balance model and crop coefficients were used to determine the water requirement of rice, water requirement satisfactory index and amount and duration of surplus and deficit water on a weekly basis (Table 4.3) during growing period under three sowing dates.

Table 4.3 Weekly water balance pertaining to upland rice under different sowing dates.

Stages	22nd June (D1)							2nd July (D2)						12th July (D3)					
	Ppt	PET	Kcr	WR	Spl	Def	WRSI	Ppt	PET	WR	Spl	Def	WRSI	Ppt	PET	WR	Spl	Def	WRSI
Sowing	18	34	0.9	30.6	0	**12.6**	100	22	28	25.2	0	**3.2**	100	13	30	27	0	**14**	100
Germination	16	21	0.9	18.9	0	**2.9**	99.25	13	30	27	0	**14**	96.28	2	35	31.5	0	**29.5**	92
Vegetative	22	28	0.9	25.2	0	**3.2**	98.42	2	35	31.5	0	**29.5**	88.44	100	22	19.8	0	0	92
	13	30	1.1	33	0	**20**	93.22	100	22	24.2	0	0	88.44	34	27	29.7	0	0	92
	2	35	1.1	38.5	0	**36.5**	83.74	34	27	29.7	0	0	88.44	2	24	26.4	0	0	92
	100	22	1.1	24.2	0	0	83.74	2	24	26.4	0	0	88.44	32	27	29.7	0	0	92
	34	27	1.1	29.7	0	0	83.74	32	27	29.7	0	0	88.44	213	23	25.3	100.1	0	92
	2	24	1.1	26.4	0	0	83.74	213	23	25.3	95.7	0	88.44	37	24	26.4	10.6	0	92
	32	27	1.05	28.35	0	0	83.74	37	24	25.2	11.8	0	88.44	0	28	29.4	0	0	92
Flowering	213	23	1.05	24.15	98.2	0	83.74	0	28	29.4	0	0	88.44	39	29	30.45	0	0	92
Milking	37	24	1.05	25.2	11.8	0	83.74	39	29	30.4	0	0	88.44	39	28	29.4	0	0	92
	0	28	0.95	26.6	0	0	83.74	39	28	26.6	0	0	88.44	27	27	25.65	0	0	92
Maturity	39	29	0.95	27.55	0	0	83.74	27	27	25.6	0	0	88.44	159	21	19.95	129.1	0	92
	39	28	0.95	26.6	0	0	83.74	159	21	19.9	132	0	88.44	265	19	18.05	246.9	0	92
Total	385							376.3						368.7					

It can be observed from Table 4.3 that crop sown on all three sowing dates suffered moisture stress right from germination to maturity. Crop sown on June 22 experienced highest moisture stress (throughout from vegetative to maturity stage), followed by 2nd July sown crop. The crop water requirement was also highest (385 mm) for June 22 sown crop, compared to July 2 sown (376 mm) and July 12 sown (368 mm) crop.

Samastipur

Influence of sowing time on growth and yield of four rice varieties sown under four sowing dates were studied.

Table 4.4: Effect of seeding dates on growth, yield attributes and grain yield of rice varieties

Treatment	Final plant height cm)	Tillers/hill	Panicle length (cm)	Grains/ Panicle	Grain yield (q/ha)
Sowing dates					
31.5.13	64.52	8.23	21.22	87.15	22.95
15.6.13	69.86	10.43	21.80	95.00	29.13
30.6.13	66.42	8.97	20.87	89.18	25.39
16.7.13	61.90	7.90	19.17	79.96	20.17
CD (P=0.05)	3.65	1.47	1.80	9.07	1.70
Varieties					
RAU 3055	68.40	8.69	22.02	89.07	23.06
Rajendra Bhagawati	73.23	9.20	21.52	90.37	26.05
Saroj	60.78	7.98	20.07	84.25	19.96
Swarna	67.28	9.67	22.46	93.60	28.56
CD (P=0.05)	3.65	1.47	1.80	9.07	1.70

The crop sown on 15 June produced highest grain yield (29.13 q/ha), which was 21.1% more than May 31 sown crop; 12.8, 30.7% more than crops sown on June 30 and July 16, respectively (Table 4.4). Grain yield varied significantly among the varieties. Swarna recorded highest grain yield (28.56 q/ha) followed by Rajendra Bhagwati (26.05q/ha) and RAU 3055 (23.06 q/ha). Significantly lower grain yield (19.96 q/ha) was recorded with Saroj.

Maize

Jammu

Water requirement of maize was studied for a 107 days variety Kanchan-517. An analysis of 30 years rainfall and evaporation data was carried out by adopting the procedure laid down by the Ministry of irrigation water management Division New Delhi, Govt. of India, for estimating irrigation water management and the results so obtained are given in table 4.5.

Table 4.5: Water requirement of maize (c.v. Kanchan-517) under optimum crop growing window for Jammu sub-tropics (mm). [Duration: Jun 21- Oct 05 (107 days)]

Month	Mid point	% growing period	KC	KP	CU/ET	Rainfall			NIR
						Normal	Effective	80%	
June 20th -30th	6	6	0.23	74	17.02	29.5	16.00	13.28	3.74
July 01st -31th	27	27	0.78	151.9	118.48	315.6	249.23	206.86	-
August 01st -31st	58	58	1	120.9	120.9	322.4	256.89	213.21	-
September 01st - 30th	86	86	0.57	102	58.14	117.4	67.07	55.66	2.48
October 01st - 05th	106	106	0.2	14	0.45	3.56	1.66	1.37	-

It is evident from the results that considering the rainfall pattern of Jammu province, maize crop does not require any irrigation in its peak growth and development periods falling in the months of July and August, however, some water is needed during the early part of the crop in June and at latter stages when crop is almost near maturity in September. Hence, as per the facts stated above regarding irrigation water requirement for maize, it can be deduced that keeping in view the normal rainfall and evaporation of this zone there is hardly any need to resort to irrigation in Jammu sub-tropics.

Udaipur

The interactive effect of sowing time and varieties on maize yield was studied using five varieties (HQPM-1, PEHM-2, Pratap-5, Pratap QPM and BIO-9637) and three sowing dates (15, 30 June and 15 July, 2013). For the crop sown on 30 June, HQPM-1 recorded the highest grain yield (56.77 qha^{-1}) (Table 4.6). For crop sown on June 15 and July 15, variety BIO-9637 recorded highest grain yield (48.69 and 52.46 qha^{-1}, respectively). Across all sowing windows, Pratap Makka-5 recorded the lowest grain yield.

Table 4.6: Interaction effect of date of sowing and varieties on grain yield (q ha^{-1})

Treatment	Date of sowing		
Varieties	June 15	June 30	July 15
HQPM-1	33.58	56.77	49.69
PEHM-2	42.28	51.30	37.11
Pratap Makka-5	36.33	38.07	37.44
Pratap QPM-1	45.04	54.00	41.05
BIO-9637	48.69	54.20	52.46

	SEm±	CD (P = 0.05)
Same varieties for different dates of sowing	2.72	7.83
Same date of sowing and different varieties	2.79	8.63

Pearl millet

Solapur

Influence of sowing time on consumptive use of moisture (CUM) and moisture use efficiency (MUE) in three rice varieties sown under three sowing dates were studied.

Table 4.7: CUM and MUE as influenced by sowing time in kharif pearl millet (2010-13)

Treat-ment	GY (kg ha^{-1})	CUM (mm)	MUE (kg ha^{-1} mm)	Treat-ment	GY (kg ha^{-1})	CUM (mm)	MUE (kg ha^{-1} mm)
S_1V_1	1637.8	303.0	5.41	S_2V_3	1652.2	314.0	5.26
S_1V_2	1651.8	309.0	5.35	S_3V_1	998.3	281.0	3.55

Treatment	GY (kg ha^{-1})	CUM (mm)	MUE (kg ha^{-1} mm)	Treatment	GY (kg ha^{-1})	CUM (mm)	MUE (kg ha^{-1} mm)
S_1V_3	1888.8	315.0	6.00	S_3V_2	1169.1	317.0	3.69
S_2V_1	1293.6	304.0	4.26	S_3V_3	1219.6	322.0	3.79
S_2V_2	1444.6	308.0	4.69				

S_1 = 26 SMW V1 - Shanti
S_2 = 30 SMW V2 - Mahyco hybrid
S_3= 35 SMW V3 - ICTP - 8203

The crop sown during 26 SMW recorded highest CUM (303-315 mm), while crop sown during 35 SMW recorded the lowest (281-322) (Table 4.7). Highest MUE was noticed in 26 SMW sown crop (5.35-6.00 Kg ha^{-1} mm) and the lowest in crop sown during 35 SMW (3.55-3.79 Kg ha^{-1} mm). Among different varieties, ICTP-8203 recorded highest CUM and MUE compared to Mahyco and Shanti.

Pigeonpea

Bijapur

The response of pigeonpea to weather at Bijapur was assessed in three cultivars [TS-3R, Maruti (ICP-8863) and BSMR-736] sown on three different dates (19 June, 10 July and 25 July 2013). Data collected over a three year period was compiled to perform correlation analysis between the stage-wise weather parameters and yield, irrespective of genotypes.

Table 4.8: Correlation coefficients between stage-wise meteorological variables and pigeonpea yield (genotypes pooled)

Weather parameter	Germination	Seedling	Vegetative & branching	Flowering	Pod formation & grain filling	Physiological maturity
Max. Temp	-0.05	-0.43	-0.65	-0.34	-0.15	-0.78
Min. Temp.	-0.56	-0.51	-0.42	0.34	0.60	0.21
Vapour pressure (Morning)	-0.64	-0.60	-0.04	0.64	0.75	0.73

Weather parameter	Germination	Seedling	Vegetative & branching	Flowering	Pod formation & grain filling	Physiological maturity
Vapour pressure (Evening)	-0.41	-0.47	0.22	0.72	0.76	0.61
Relative Humidity-1	-0.18	-0.09	0.76	0.85	0.82	0.79
Relative Humidity-II	0.14	0.15	0.40	0.70	0.77	0.79
Temp. Range	0.09	-0.34	-0.44	-0.71	-0.74	-0.67
Cum. Bright Sun Shine hours	-0.53	-0.80	-0.35	-0.50	-0.55	-0.15
BSS	-0.53	-0.80	-0.31	-0.48	-0.67	0.01
Cloud cover I	0.30	0.51	0.85	0.73	0.85	0.71
Cloud cover II	-0.04	-0.12	0.37	0.37	0.68	0.39
Rainfall	0.47	0.41	0.29	0.22	0.69	0.55
GDD	0.12	-0.35	-0.45	-0.62	0.07	-0.13

In the germination stage, morning vapour pressure and minimum temperature showed a strong negative correlation. Sunshine hours and morning vapour pressure showed highest negative correlation in the seedling stage. In the vegetative and branching stages, the highest positive correlation was observed with morning cloud cover (0.85) and relative humidity (0.76). During flowering stage, while the diurnal temperature range and GDD showed negative and highly significant correlation with yield, vapor pressure and relative humidity showed a positive correlation. In the pod formation and grain filling stage, rainfall, vapor pressure and humidity along with minimum temperature showed highly significant positive correlation, whereas temperature range and sunshine parameters showed highly significant positive correlation with yield. During physiological maturity stage, maximum temperature showed a strong negative correlation and relative humidity and vapour pressure showed a positive correlation.

Soybean

Akola

Effect of dates of sowing on grain yield, water use efficiency and water productivity of three soybean varieties sown on four sowing dates was studied. Actual crop water use was highest for crop sown during 26 SMW and it decreased in later sowings (Table 4.9). The same trend was observed for water use efficiency and water productivity. Among varieties, TAMS-98-21 showed highest crop water use, WUE and WP.

Table 4.9: Water use indices as influenced by treatments

Treatment	Seed yield (kg ha^{-1})	Seasonal rainfall (mm)	Eta (mm)	RWUE (kg/ha-mm)	WP (kg/ha-mm)
Sowing time					
26 MW	1310	577.6	301.8	2.27	4.34
27 MW	1194	575.4	302.4	2.07	3.95
28 MW	1109	573.5	294.9	1.93	3.76
29 MW	968	499.7	288.6	1.94	3.37
Variety					
JS-335	1126	549.7	297.9	2.05	3.78
JS-9305	1094	549.4	281.3	1.99	3.89
TAMS-98-21	1216	570.6	311.6	2.12	3.90

Parbhani

Correlation study was performed between yield and weather parameters at different growth stages using six soybean varieties (MAUS-158, 47, 81, 71, JS 93-05, JS-335), sown under four sowing dates (27, 28, 29 and 30 SMW). The analysis indicated that during the pod formation stage, rainfall, rainy days and all humidity parameters showed a significant positive association where as all temperature parameters and growing degree days showed a negative association (Table 4.10). During grain development stage all humidity parameters and soil moisture except humidity range showed highly significant positive association whereas as maximum temperature, bright sunshine hours and evaporation showed negative association. It indicates the contribution of rain water as well as atmospheric humidity in grain production of soybean.

Table 4.10: Correlation coefficients between grain yield and weather variables prevailed during different phenophases of soybean.

Parameter	Pod formation	Grain formation	Pod development	Grain development	Maturity	Mean
Rainfall	0.59**	-0.21	-0.79**	0.58**	0.62**	0.14**
Rainy days	0.53**	-0.11	-0.76**	0.61**	0.39	0.11*
Max.T.	-0.58**	-0.30	- 0.27	0.15	-0.85**	-0.26**
Min.T.	-0.44**	0.02	0.06	0.19	0.76**	0.17**
MeanT	-0.58**	-0.25	-0.21	0.18	- 0.80**	- 0.21**
T.Range	-0.59**	0.16	-0.33	0.12	-0.84**	-0.07
RH_I	0.70**	0.14	-0.70**	0.18	0.77**	0.32**
RH_{II}	0.57**	0.24	-0.19**	0.58**	0.77**	0.28**
RH_{mean}	0.64**	0.24	-0.50**	0.46**	0.51**	0.23**
RH_{Range}	0	- 0.25	-0.50**	- 0.65**	-0.68**	-0.22**
EVP	-0.62**	-0.27	0.15	- 0.24**	0.08	-0.14**
BSS	-0.59**	-0.27	-0.22	- 0.24**	-0.46	-0.16**
SMC	-0.11	-0.63**	- 0.47**	0.08	0.30	0.03
AGDD	-0.69**	-0.79**	0.79**	-0.79**	-0.83**	-0.05

Sunflower

Solapur

Moisture and radiation use efficiencies of three sunflower cultivars (Bhanu, MSFH-17 and Phule Raviraj) sown on three dates (June 26, July 26 and August 26) were calculated and their relationship with grain yield was assessed.

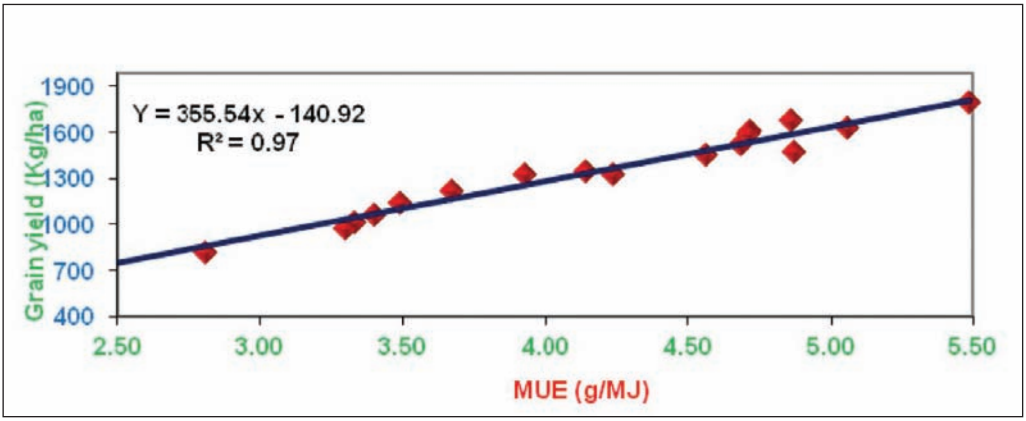


Fig. 4.3: Relationship between grain yield with MUE in sunflower at Solapur

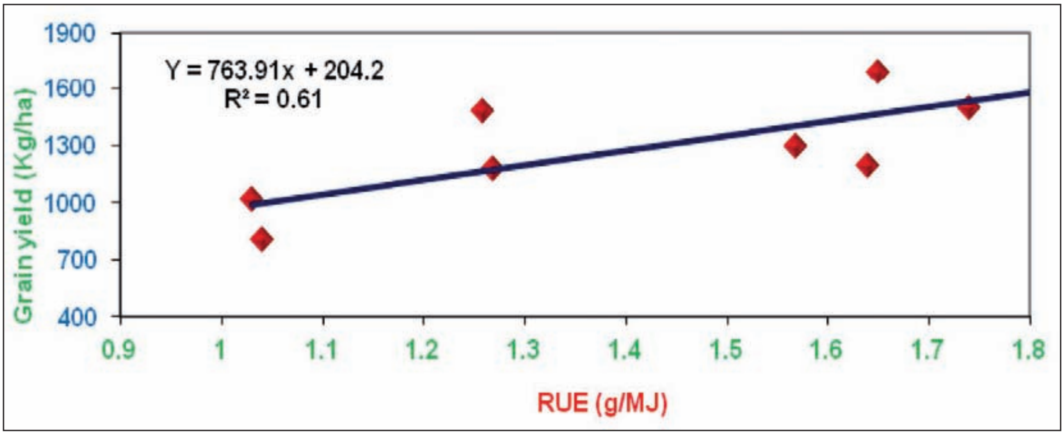


Fig. 4.4: Relationship between grain yield with RUE in sunflower at Solapur

The moisture use efficiency (MUE) during total growth period of *kharif* sunflower (Fig. 4.3) showed a linear relationship with grain yield (y = 355.5x - 140.9; R^2 = 0.971). The MUE of 3.50 to 4.00 kg ha/mm was found to be optimum for getting higher grain yield and thereafter there was a decrease in sunflower yield.

The RUE studies depicted in Fig. 4.4 showed a linear relationship with grain yield. This indicated that radiation interception is directly related with grain yield (y = 763.9x + 204.2; R^2 = 0.606). The figure showed that if RUE increases from 1.6 to 1.7 g MJ^{-1} it increases the yield from 07 to 13 q ha^{-1}. This indicated that every increase of 0.1 g MJ^{-1} of energy there is an increase of 0.5 q ha^{-1} of grain yield of sunflower.

Cotton

Akola

Weather parameters influencing the cotton growth and development were identified through correlation analysis. Yield prediction equations were developed (Table 4.11) through regression technique to predict the yield of cotton crop using meteorological variables that prevailed during different phonological phases of the crop.

Table 4.11: Weather based yield prediction models for cotton

Phenological phase	Regression equation	R^2
Sowing- First Square	Y = -20442.978 + 610.660Tmax – 325.545Tmin + 114.473RhI – 6.565RhII + 2.603Rain	0.928
First Square-First Boll burst	Y = -13472.615 – 280.102Tmax + 766.726Tmin + 73.192RhI – 30.033RhII + 3.448Rain	0.857
First Boll burst-First picking	Y = -2934.379 + 100.398Tmax + 88.509Tmin – 34.425Rh1 + 45.355RhII + 1.865Rain	0.822
First picking-Last picking	Y = -4521.855 + 19.990Tmax + 235.823Tmin + 69.659RhI – 149.081RhII + 381.741Rain	0.739
Total crop growth period	Y = -927.741 + 29.622Tmax – 34.993Tmin – 24.039RhI +55.917RhII + 6.399Rain	0.905

Water use efficiency and water productivity as influenced by different sowing dates and adaptation strategies were also studied. Early sown cotton crop used more water (512.4 mm), which decreased with subsequent sowings (Table 4.12). WUE and WP were also highest for crop sown on June 6, followed by 19 June and 8 July sown crops. Among different adaptation strategies, dead mulch showed highest WUE and WP (1.82 and 2.92 kg ha-mm^{-1}), followed by conservation furrows.

Table 4.12: Water use indices as influenced by treatments

Treatment	Seed cotton yield (kg ha^{-1})	Seasonal Rainfall (mm)	Eta (mm)	RWUE (kg/ha-mm)	WP (kg/ha-mm)
Sowing time					
Dry sowing(6 June)	1901	890.7	512.4	2.13	3.71
Monsoon sowing(19 June)	1193	693.3	461.6	1.71	2.58
Late sowing (8 July)	610	585.1	392.1	1.04	1.56
Adaptation strategy					
Conventional practice	1135	722.9	456.3	1.50	2.40
Conservation furrows	1237	723.1	454.9	1.64	2.62
Dead mulch	1377	723.2	454.8	1.82	2.92
Live mulch	1189	722.9	455.4	1.58	2.53

Parbhani

Correlation study was carried out between yield and weather parameters using three Bt cotton cultivars (Ajit 155, Rasi 2 and Mallika). Analysis revealed that during early stage i.e., seedling to square formation stage, weather parameters viz., rainy days, afternoon relative humidity, mean relative humidity showed a significant positive relationship with cotton yield (Table 4.13). During square formation to flowering stage, maximum, minimum temperatures, temperature range, evaporation and sunshine hours showed negative association. During flowering to boll setting, rainfall, rainy days and all humidity parameters showed negative association. At boll setting to boll bursting stage rainfall, rainy days, minimum and minimum temperature, mean temperature, after noon relative humidity and soil moisture content showed a significant positive relationship and at last stage i.e., boll bursting to picking stage of crop, rainfall, rainy days, soil moisture content, growing degree days showed highly positive significant correlation with cotton yield.

Table 4.13: Correlation coefficients between weather parameters prevailed in different phenophases and cotton yield (2013-14).

Parameters	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9
Rainfall	-0.24	0.75**	0.58	0.12	-0.57*	0.66**	0.22	-0.64**	0.69**
R.D.	0.42	0.62**	0.67**	-0.07	-0.57*	0.43	0.27	-0.29	0.57**
Tmax.	0.61**	0.09	-0.53*	-0.59**	-0.26	0.63**	0.56*	0.59**	-0.55*
Tmin.	0.22	0.41	0.03	-0.53*	0.14	0.60**	0.55*	0.45	0.0
Tmean	0.57*	0.17	-0.49	-0.59**	-0.19	0.63**	0.57*	0.52*	-0.17
T.range	0.65**	-0.02	-0.62**	-0.60**	-0.33	-0.53*	-0.53*	-0.26	-0.17
RH_I	-0.22	0.56*	-0.01	0.49	-0.57*	0.46	0.52**	-0.70**	0.35
RH_{II}	-0.61*	0.34	0.61**	0.29	0.03	0.59**	0.46	0.14	0.07
RH_{mean}	-0.57*	0.48	0.72**	0.40	-0.22	0.49	0.50*	-0.47	0.35
RH_{range}	0.58**	-0.21	-0.42	0.59**	-0.49*	-0.59**	-0.37	-0.78**	0.59**
EVP	0.57*	-0.09	-0.02	-0.56*	0.21	0.06	-0.63**	0.69**	-0.41
BSS	0.52*	-0.09	-0.42	-0.64**	-0.40	-0.24	-0.42	-0.17	0.25
SMC	-0.61**	0.34	0.18	-0.62**	0.47	0.71**	0.66**	-0.41	0.76**
GDD	0.57*	0.67**	0.61*	0.44	0.01	0.12	0.60**	0.67**	0.64**

*Significant at 5% level; **Significant at 1% level

P_1 = Sowing to emergence, P_2 = Emergence to seedling, P_3 = Seedling to square formation P_4 = Square formation to flowering, P_5 = Flowering to boll setting, P_6 = Boll setting to boll bursting, P_7 = Boll bursting to 1st picking, P_8 = 1st picking to 2nd picking, P_9 = 2st picking to 3rd picking

Rabi 2013-'14

Wheat

Anand

The phase-wise mean values of weather parameters were correlated with grain yield of wheat. Results indicated that temperature showed significant negative association during emergence to crown root initiation phase with grain yield (Table 4.14). From BT to dough stage humidity and vapour pressure showed significant positive association with grain yield.

Table 4.14: Correlation coefficients between wheat yield and phase-wise weather parameters

Weather parameters	Phenological phases						
	EM	CRI	TL	BT	FL	ML	Dough
Evaporation	-0.60**	0.33	0.16	0.16	0.06	-0.07	-0.43
BSS	-0.13	-0.05	-0.43	-0.49*	-0.41	-0.31	-0.23
Tmax.	-0.60**	-0.30	-0.28	-0.24	0.07	0.08	-0.10
Tmin.	-0.72**	-0.62**	-0.333	0.15	0.42	0.42	0.36
Tmean.	-0.76**	-0.72**	-0.34	-0.01	0.32	0.27	0.11
RH1	0.57**	0.63**	0.68**	0.72**	0.62**	0.53*	0.65**
RH2	0.004	0.008	0.41	0.58**	0.60**	0.57**	0.64**
Mean RH	0.27	0.34	0.57**	0.65**	0.65**	0.56*	0.66**
VP1	-0.60**	-0.40	0.52*	0.55*	0.66**	0.67**	0.61**
VP2	-0.21	-0.17	0.44	0.55*	0.66**	0.70**	0.69**
MeanVP	-0.38	-0.27	0.50*	0.55*	0.67**	0.68**	0.66**
GDD	0.73**	-0.72**	0.55*	0.53*	-0.32	-0.79**	-0.55*

Hisar

Correlation studies were carried out between seed yield and yield attributes with weather parameters during different growth stages of wheat variety WH-1105. The results are presented in Table 4.15.

Jammu

Correlation study was done between weather parameters and yield of three wheat varieties (HD-2967, Raj-3077 and RSP-561), sown on four sowing dates (sown on Oct 29, Nov 12, Nov 26 and Dec 10). The results showed that most of weather parameters during the initial stages significantly influenced the yield either positively or negatively and the association of all weather parameters with yield was higher as compared to other phenological stages. Positive correlation of temperature at emergence and CRI and rainfall at jointing stages reveal that these weather parameters during early phases are highly beneficial for germination and proper establishment of plants, respectively (Table 4.16). Higher day temperature and lower night temperature during the ripening phase are not favourable for wheat yield, whereas humid conditions supports anthesis and hard dough stages.

Table 4.15: Correlation coefficients for seed yield and yield attributes with weather parameters during different crop phase of wheat

Vegetative stage				
Weather parameters	**Seed yield**	**Straw yield**	**Tiller/plant**	**1000 seed weight**
Maximum temp.	0.92*	0.96*	0.56*	0.77*
Minimum temp.	0.55*	0.52*	0.51*	0.13
Relative humidity 1	-0.36	-0.32	-0.52*	0.08
Relative humidity II	-0.93*	-0.96*	-0.42	-0.93*
Sun shine hours	0.76*	0.82*	0.29*	0.97*
PE	0.07	-0.09	-0.13	-0.48
Rain	-0.54*	-0.58*	-0.17	-0.86*
Reproductive stage				
Maximum temp.	-0.88*	-0.93*	-0.40	-0.89*
Minimum temp.	-0.87*	-0.86*	-0.32	-0.83*
Relative humidity 1	0.69*	0.65*	0.53*	0.79*
Relative humidity II	0.85*	0.91*	0.35	0.86*
Sun shine hours	-0.91*	-0.96*	-0.43	-0.98*
PE	-0.85*	-0.91*	-0.36	-0.96*
Rain	-0.69*	0.71*	0.30	-0.93*

Maximum and minimum temperatures were positively correlated with seed yield during the vegetative stage and negatively during the reproductive stage. The same trend was observed for straw yield, tillers per plant and 1000 seed weight with SSH, PE and rainfall. The reverse was true for relative humidity.

Table 4.16: Correlation coefficient between weather parameters during different phases of crop growth and seed yield of wheat.

Weather variables	Emer-gence	CRI	Tillering	Jointing	Anthesis	Milking	Hard dough	Maturity
Max.T	0.79**	0.76**	0.67	0.54	-0.85**	-0.65*	-0.18**	-0.71**
Min.T	0.63**	0.79**	0.67*	-0.03	-0.55	-0.73**	0.08	-0.76**
Rainfall	0.55	-0.33	-0.02	0.76**	-0.06	0.56	0.66*	0.53
EPO	0.69*	0.79**	0.69*	0.16	-0.88	0.75**	-0.92**	-0.66*
Sunshine	0.43	0.59*	0.39	0.69*	-0.75**	-0.48	-0.83**	-0.44
RH_1	0.16	-0.80**	0.08	0.39	0.75**	0.21	0.65**	0.69*
RH_2	-0.69*	-0.69*	-0.38	-0.79**	0.28	0.43	0.62*	0.69*
VP_1	0.66*	0.76**	0.75**	-0.39	-0.59*	-0.62*	-0.69*	-0.38
VP_2	0.13	-0.74**	0.43	-0.47	-0.59*	-0.41	0.22	-0.76**

Raipur

Heat and radiation use efficiencies of four wheat varieties (Kanchan, GW-273, Sujata and Amar), which were sown under five sowing dates (Nov 25, Dec 5, 15, 25 and Jan 5) were calculated and are presented in Table 4.17.

Table 4.17: Heat use efficiency (HUE) of wheat varieties under different thermal environments

Varieties	Heat use efficiency (g/m^2 deg day)					
	25 Nov.	5 Dec.	15 Dec.	25 Dec.	5 Jan.	Mean
Kanchan	0.47	0.38	0.40	0.45	0.51	0.44
GW-273	0.39	0.36	0.37	0.49	0.47	0.42
Sujata	0.43	0.37	0.39	0.44	0.36	0.40
Amar	0.46	0.42	0.33	0.44	0.40	0.41
Mean	0.44	0.38	0.37	0.46	0.44	0.42

Among the varieties, Kanchan recorded highest HUE (Average HUE of 0.44 g/ m^2 deg day across five sowing dates) followed by GW-273. Crop sown on 25 Dec showed highest HUE (0.46 g/m^2 deg day) among all sowing windows, followed by crops sown on 25 Nov and 5 Jan. Results of RUE analysis are furnished in table 4.18.

Table 4.18: Radiation Use Efficiency (RUE) of wheat varieties under different thermal environments

Varieties	Radiation Use Efficiency (g MJ^{-1})					
	25 Nov.	5 Dec.	15 Dec.	25 Dec.	5 Jan.	Mean
Kanchan	0.47	0.37	0.38	0.44	0.50	0.43
GW-273	0.38	0.35	0.36	0.48	0.47	0.41
Sujata	0.42	0.41	0.35	0.44	0.37	0.40
Amar	0.46	0.41	0.36	0.46	0.41	0.42
Mean	0.43	0.39	0.36	0.46	0.44	0.41

Among the varieties, Kanchan recorded better RUE (Average HUE of 0.43 g/MJ across five sowing dates) followed by Amar. Crop sown on 25 Dec showed highest RUE (0.46 g MJ^{-1}) among all sowing windows, followed by crops sown on 5 Jan and 25 Nov.

Ranchi

Heat use efficiencies of three wheat varieties (HUW 468, K9107 and BG 3), cultivated under three dates of sowing showed that efficiencies are influenced by varying thermal regimes as well as varietal differences. Among the three dates of sowing, Birsa Genhu 3 recorded highest HUE (3.78 kg/ha °days) under 5th Dec sowing date followed by HUW 468 (Table 4.19). Performance of variety K 9107 was lowest among the varieties in terms of heat use efficiency.

Udaipur

Effect of temperature during reproductive stage on grain yield of three wheat varieties (HI-1544, MP-1203 and Raj-4037), sown on four sowing dates (5, 20 Nov, 5, 20 Dec 2013) was studied. The early sown crop (5 and 20 Nov) experienced lower mean temperature as compared to delayed sowing i.e. 5 and 20 Dec in all varieties during heading to milking stage. Similarly, first two dates of sowing also experienced lower mean temperature during milking to dough stage as compared

Table 4.19: Heat Use Efficiency (HUE) of wheat cultivars under different thermal regimes.

Sowing Date	Variety	HUE (kg/ha °days)	Yield (kg/ha)
20 Nov	HUW 468	3.75	5501
	K9107	3.0	4809
	BG 3	3.76	5758
5 Dec	HUW 468	3.71	5380
	K9107	3.0	4745
	BG 3	3.78	5721
20 Dec	HUW 468	3.61	5343
	K9107	3.15	4917
	BG 3	3.33	5050

to later sowing dates in all varieties. Grain yield of all varieties was decreased with the increase in mean temperature during reproductive phase (Fig. 4.5). The mean temperature of 15.2 to 18.3 °C and 18.5 to 21.2 °C during heading to milking stage and during milking to dough stage, respectively found conducive for getting a higher grain yield of wheat. So, the period between heading to dough stage is more sensitive to higher mean temperature which resulted in reduction in grain yield of wheat in late sown conditions.

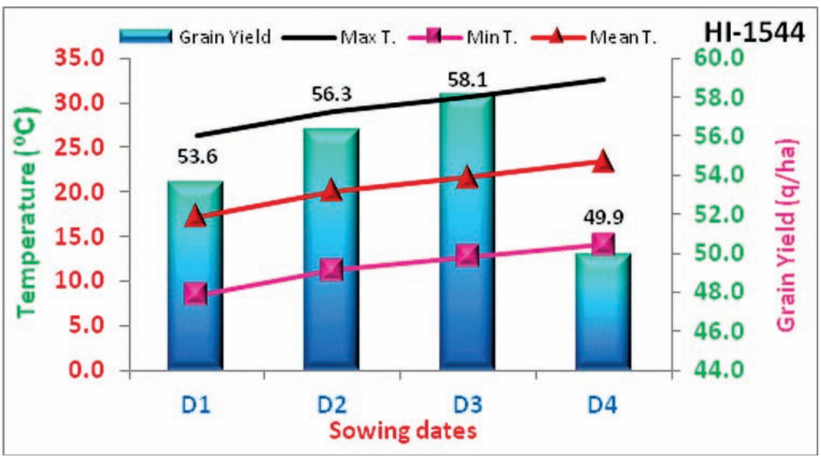


Fig. 4.5: Effect of temperature during reproductive stage on grain yield of wheat varieties (2013-14)

Maize

Kovilpatti

Effect of sowing date on heat use efficiency and economic returns was investigated. Three hybrids [900 (M) Gold, NK6240, Prabal] was sown on four sowing dates (39, 40, 41 and 42 SMW). The crop sown on 39 SMW gave higher gross return (Rs.25389/ha), net return (Rs.7939/ha) and B:C ratio (1.45), whereas lower monetary benefit was obtained from 42 SMW sown crop (Table 4.20). Same was the trend for HUE also. Among maize hybrids, NK6240 registered higher gross return, net return and B:C ratio while lower net return (Rs.4880/ha) and B:C ratio (1.27) were observed in 900(M) Gold hybrid.

Table 4.20: Effect of date of sowing on economics and heat use efficiency of hybrid maize under rainfed situation

Treatments	Gross Return (Rs/ha)	Net Return (Rs./ha)	B:C Ratio	Heat use efficiency (kg/ha/°C day)
Date of sowing				
39th SMW (Sep 24th – 30th)	25389	7939	1.45	3.25
40th SMW (1 to 7 'Oct)	25075	7625	1.44	3.19
41st SMW (8 to 14 'Oct)	24769	7319	1.42	3.15
42nd SMW (15 to 21' Oct)	20995	3545	1.20	2.77
Hybrids				
900(M) Gold	22630	4880	1.27	-
NK6240	27274	9424	1.53	-
Prabal	22035	4985	1.29	-

Chickpea

Akola

Heat use efficiency as influenced by three dates of sowing (40, 41 and 42 SMW) for three varieties (JAKI-9218, SAKI-9516 and Vijay) was calculated in terms of seed yield and biomass production. The results are presented in table 4.21.

Anantapur

Influence of fog on pod set in different chickpea varieties was studied. Three desi varieties (JG 11, JAKI 9218, Nandyal Sanaga 1) and three kabuli varieties (KAK2,Vihar,MNK1) were used for the study under protected as well as normal conditions.

Table 4.21. Heat use efficiency of chickpea varieties in terms of seed and biomass production (kg ha^{-1} °C day^{-1}) under different dates of sowing

Varieties	Sowing date			
	40 SMW (01.10.13)	41 SMW (08.10.13)	42 MW (16.10.13)	Mean
JAKI-9218	0.43	0.52	0.50	0.48
	1.00	**1.17**	**1.20**	**1.12**
SAKI-9516	0.50	0.58	0.59	0.56
	1.12	**1.25**	**1.28**	**1.21**
VIJAY	0.47	0.57	0.51	0.52
	1.04	**1.24**	**1.17**	**1.15**
Mean	0.47	0.56	0.53	
	1.05	**1.22**	**1.22**	

(Bold figures indicate heat use efficiency in terms of biomass)

Varieties sown on 41 SMW recorded highest HUE both in terms of grain yield and biomass, followed by crop sown on 42 SMW. Among the varieties, SAKI-9516 recorded highest HUE both in terms of grain yield and biomass, followed by Vijay.

Table 4.22: Influence of fog on pod set, final yield in different desi varieties of chickpea

Parameter	JG 11		NS 1		JAKI 9218	
	Control	Protected	Control	Protected	Control	Protected
Flowering duration	22 days	22 days	18 days	18 days	17 days	16 days
Pod set % (Avg) (entire flowering period)	47.8%	48.2%	41.6%	42.2%	35.3%	40.6%
Fog occurrence (days after flowering)	18 days		8 days		6 days	
Pod set on the day of Fog	4.0%	9.1%	41.8%	51.9%	42.8%	54.9%
Pod yield (kg/ha)	1052	1349	1203	1622	1298	1409

In all three desi varieties, the pod set on the day of fog occurrence was low in crop grown in control plots. Yields were also low in control plots compared to protected plots. Among desi varieties, NS 1 recorded highest yield (1622 $kgha^{-1}$) (Table 4.22). Similar responses were observed in kabuli varieties also (Table 4.23).

Table 4.23 : Influence of fog on pod set, final yield in different Kabuli varieties of chickpea

Parameter	KAK 2		VIHAR		MNK 1	
	Control	Protected	Control	Protected	Control	Protected
Flowering duration	18 days	18 days	16 days	16 days	22 days	22 days
Pod set % (Avg) (entire flowering period)	40.5%	47.6%	35.3%	44.4%	46.6%	48.0%
Fog occurrence (days after flowering)	8 days		6 days		14 days	
Pod set on the day of Fog	20.4%	41.2%	48.9%	55.2%	38.8%	35.4%
Pod yield (kg/ha)	1140	1467	1391	1531	1089	1207

Faizabad

Crop weather relationship studies were conducted at Faizabad using 3 cultivars (Radhey, Pusa 362 and Uday) grown under three different sowing dates (Oct 25, Nov 4 and Nov 14, 2013). Radiation use efficiency was determined. RUE increased progressively till 90 days after sowing and thereafter gradually declined in different treatments. Chickpea sown on Oct. 25 recorded higher RUE at all the stages followed by Nov 4 sown and lowest RUE was recorded in Nov 14 sown crop. Different varieties showed variation in RUE (Table 4.24). Higher radiation use efficiency was recorded under Radhey followed by Pusa 362 at all the stages of crop growth, while the lowest RUE was recorded for Uday.

Table 4.24: Radiation use efficiency(g/MJ) of chickpea as affected by various treatments at Faizabad

	Days after sowing							
Treatment	30	45	60	75	90	105	120	135
Sowing dates								
Oct.25	1.1	1.16	1.27	1.28	1.65	1.54	1.49	1.32
Nov. 4	0.96	1.13	1.18	1.26	1.51	1.48	1.38	1.24
Nov.14	0.91	1.09	1.12	1.22	1.48	1.36	1.36	1.22
Varieties								
Radhey	0.98	1.14	1.24	1.29	1.58	1.37	1.29	1.28
Pusa 362	0.95	1.10	1.18	1.26	1.52	1.34	1.26	1.24
Uday	0.93	1.08	1.15	1.22	1.44	1.30	1.26	1.22

Solapur

Crop weather relationship in chickpea was studied using two varieties (Vijay and Digvijay), sown on four sowing dates (38, 40, 42 and 44 SMW of 2013). Moisture stress was calculated using infrared thermometer. The analysis indicated that ΔTc values were negative from sowing to 98 DAS in crop sown on 36 SMW; from sowing to 84 DAS in crop sown on 38 SMW; from sowing to 70 DAS in 40 SMW sown crop and from sowing to 56 DAS in 42 SMW sown crop (Table 4.25). This indicated that crop sown on 42 SMW suffered moisture stress for longer period and resulted in low yield.

Mustard

Hisar

Correlation studies between seed yield and weather parameters revealed that seed yield and yield attributes were significantly and positively correlated with maximum temperature during vegetative and reproductive phases. The seed yield and yield attributes were significantly and positively correlated with minimum temperature and sunshine hours during vegetative phase, but negatively correlated with the same weather parameters at reproductive phase (Table 4.26).

On the other hand, the relative humidity was found significantly correlated with seed yield and yield attributes at reproductive phase and negatively correlated during the vegetative phase.

Table 4.25: Canopy - air temperature differential as influenced by different varieties and sowing dates in chickpea (Mean of 2009-2010 to 2013-14)

			36 SMW		28 SMW		40 SMW		42 SMW	
SMW	DAS	RF	VIJAY	PG-12	VIJAY	PG-13	VIJAY	PG-14	VIJAY	PG-14
38	SOW		SOW	SOW	-	-	-	-	-	-
39	7	8.1	-2.3	-1.9	-	-	-	-	-	-
40	14	33.4	-4.8	-3.8	SOW	SOW	-	-	-	-
41	21	0	-3.2	-3.1	-2.8	-2.4	-	-	-	-
42	28	0	-2.5	-2.1	-1.9	-1.6	SOW	SOW	-	-
43	35	0	-1.5	-0.9	-0.8	-0.5	-0.6	-0.4	SOW	SOW
44	42	2.1	-1.8	-1.2	-1.2	-0.9	-1.1	-0.8	-0.8	-0.7
45	49	93.4	-3.8	-2.8	-2.9	-2.4	-2.5	-2.1	-2.1	-1.8
46	56	0	-2.5	-1.8	-2.2	-1.9	-1.8	-1.5	-1.4	-1.2
47	63	0	-1.8	-1.1	-1.2	-0.9	-0.9	-0.7	-0.6	-0.5
48	70	0	-0.8	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1	-0.1
49	77	0	0.8	0.6	0.9	1.1	0.6	0.8	0.8	0.7
50	84	0	1.3	1.4	1.5	1.7	1.7	1.9	1.9	1.8
51	91	0	1.8	1.9	1.9	2.1	2.1	2.2	2.3	2.2
52	98	0	-	2.1	2.2	2.4	2.4	2.6	2.7	2.8
1	105	0	-	-	2.4	2.8	2.5	2.6	2.8	2.9
2	112	0	-	-	-	2.9	2.7	2.8	2.8	2.9
3	119	0	-	-	-	-	-	2.9	-	3

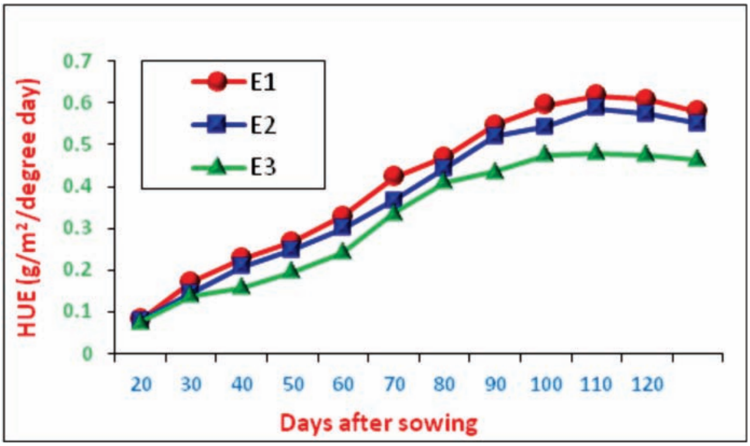
Table 4.26: Correlation coefficient for seed yield and yield attributes with weather parameters during different phenophases in mustard

Weather parameters	Phenophases	Seed yield kg ha^{-1}	Biological yield kg ha^{-1}	No. of siliquae m^{-2}	Seeds $siliqua^{-1}$	1000-seed weight (g)
T_{max}	Vegetative phase	-0.79*	-0.63*	-0.83*	0.37	-0.75*
	Reproductive phase	0.84**	0.64**	0.80**	0.35*	0.73**
T_{min}	Vegetative phase	0.22	0.38	0.32	0.32	0.38
	Reproductive phase	-0.41	-0.32	-0.50	-0.45	-0.36
RH_{mean}	Vegetative phase	-0.61	-0.33	-0.65	-0.66	-0.37
	Reproductive phase	0.78**	0.74**	0.71**	0.36	0.80**
BSSH	Vegetative phase	0.88**	0.69**	0.90**	0.35	0.77**
	Reproductive phase	-0.30	-0.52	-0.54	-0.61	-0.76

*** Significant at (P = 0.01) level of significance   * Significant at (P = 0.05) level of significance*

Jammu

Effect of weather on crop growth was studied using two cultivars (NPJ-112 and NRCDR-2) sown under three sowing dates (Oct 17, 27 and Nov 6). Heat use efficiency (g m^{-2} degree day^{-1}) was worked out.



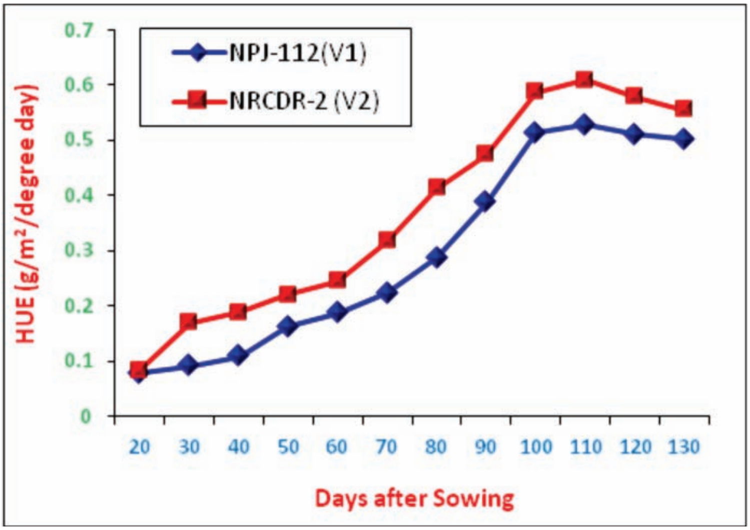


Fig. 4.6 : (a,b) Heat use efficiency (g/m2/degree day) of mustard at different periodical events as influenced by different cropping environments.

The data revealed that heat use efficiency was influenced by different treatments. The highest HUE was recorded in early sown crop (17 Oct) and decreased with delayed sowing. Among the varieties, NRCDR-2 recorded highest HUE over NPJ-112 (Fig. 4.6 a,b). The data also revealed that the efficiency rate for conversion from thermal to dry matter production showed an increase but with slower rate in all sowings. This lag phase may be due to slow leaf growth during this phase, which has led to less leaf area. After this lag phase, the HUE increased at a faster rate from 80 to 100 days after sowing and thereafter a deceasing trend was observed in all the environments.

Ludhiana

The radiation interception in relation to leaf area index and dry matter production in mustard was studied using two varieties (GSC-6 and Hyolla PAC 401), sown on 25 Oct and 9 Nov 2013. The canopy extinction coefficient was calculated. The extinction coefficient was low for crops sown during October compared to late November sowing due to high LAI under the October sowing (Table 4.27).

Table 4.27: Periodic extinction coefficient of Brassica cultivars under different environments

Treatments		Extinction coefficient (k)			
		Days after sowing			
		30	60	90	120
D_1- 26th October 2012					
GSC-6	S_1=30cm	0.67	0.60	0.52	0.67
	S_2=45cm	0.83	0.75	0.63	0.74
Hyolla PAC-401	S_1=30cm	0.60	0.54	0.52	0.65
	S_2=45cm	0.76	0.65	0.60	0.72
D_2- 10th November 2012					
GSC-6	S_1=30cm	0.68	0.64	0.57	0.77
	S_2=45cm	0.75	0.71	0.63	0.81
Hyolla PAC-401	S_1=30cm	0.69	0.58	0.51	0.72
	S_2=45cm	0.81	0.66	0.55	0.78
D_3-27th November 2012					
GSC-6	S_1=30cm	0.91	0.83	0.69	0.82
	S_2=45cm	0.97	0.85	0.73	0.86
Hyolla PAC-401	S_1=30cm	0.93	0.90	0.71	0.83
	S_2=45cm	0.99	0.92	0.76	0.89

Tea

Palampur

Critical temperatures for tea leaf production at Palampur was studied. It was observed that the tea bush undergoes dormancy during winter (November to February) and production of tea leaves initiates during the month of March when the minimum and maximum temperatures either during February or March rise above 4.5 and 13.5 °C, respectively (Fig. 4.7). The critical limit thus appear for mean minimum and maximum temperatures as 6.5 and 17.5 °C.

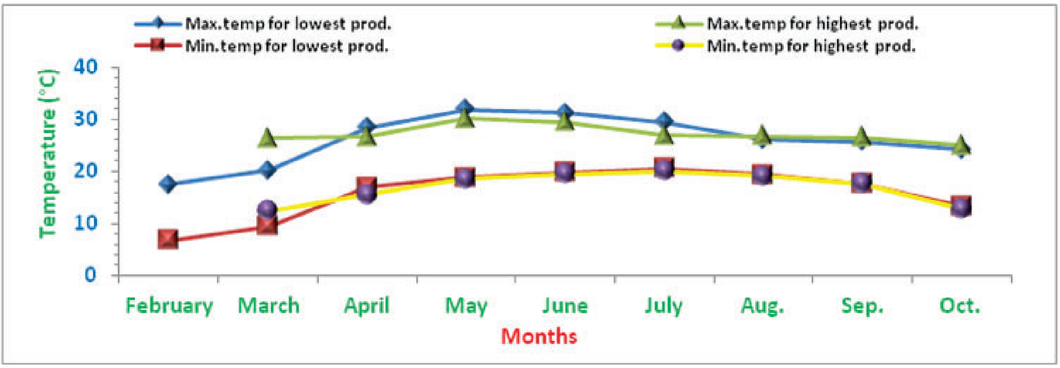


Fig. 4.7: Critical temperature for tea leaves production at University tea garden at Palampur

During February and March normally 100 mm rainfall is received and the maximum and minimum temperature ranges between 16.7-20.5 °C and 5.0-6.5 °C respectively (Fig. 4.7). A rise in maximum temperature during February and March showed positive association with the yield of March. Since the rainfall during this period is generally associated with western disturbances and is accompanied by decreasing temperatures, hence the rainfall of February and March showed a depressing effect on tea yield. During April, rainfall of 60 mm and monthly temperature around 26.0 °C (maximum) and 14.9 °C (minimum) are beneficial for tea leaf production. But a rise in maximum and minimum temperature above 28.4 and 16.9 °C, respectively caused drastic reduction the yield. The optimum minimum and maximum temperature for the growth of tea bush varies between 8.5-20.5 and 21.5-31.5 °C respectively. The mean monthly values, however range between 12.5-20.0 and 25.0-30.0 °C, respectively.

Mango

Bangalore

The monthly water balance for mango using FAO water balance technique was worked out. The water balance for different months and total water used in different months are tabulated in table 4.28 and fig.4.8.

Table 4.28: Monthly water balance for mango at Bengaluru (2013)

Months	PPT	PET	Kc	AET	Water used	Water stored
Jan	0.0	105.1	0.8	84.1	0.0	0.0
Feb	2.2	101.4	0.8	81.1	2.2	0.0
Mar	0.0	120.2	0.9	108.2	0.0	0.0
Apr	56.8	122.5	1	122.5	56.8	0.0
May	92.8	123.8	1.1	136.2	92.8	0.0
June	96.5	96.8	1.2	116.2	96.5	0.0
July	59.2	91.6	1.2	110.0	59.2	0.0
Aug	58.8	94.7	1.2	113.6	58.8	0.0
Sep	362.3	88.6	1.1	97.5	97.5	264.8
Oct	81.9	93.3	0.9	84.0	84.0	262.7
Nov	37.0	88.9	0.9	80.0	80.0	219.7
Dec	0.0	93.2	0.9	83.8	83.8	135.8
	847.5	**1220.2**		**1217.2**	**711.7**	

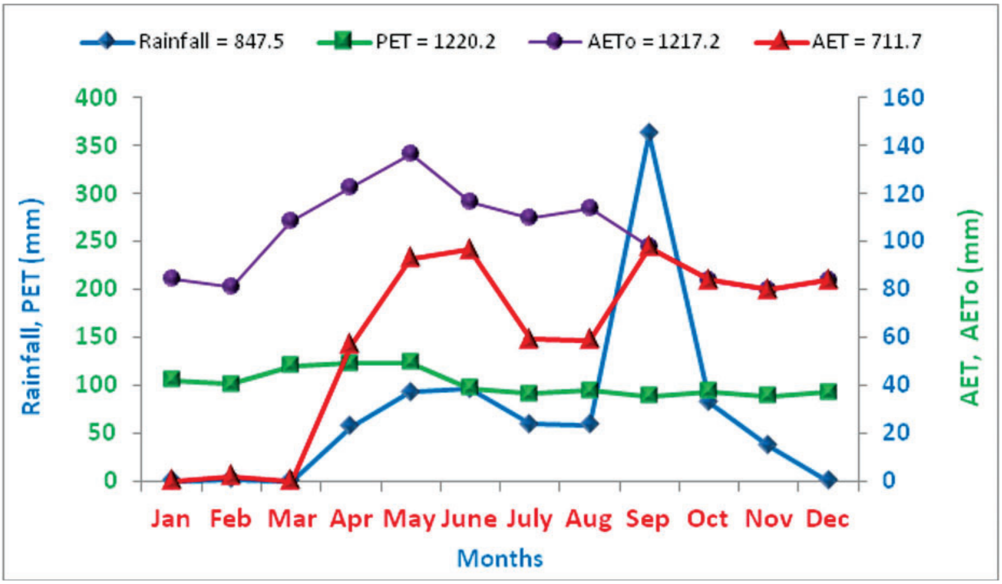


Fig. 4.8: Water Balance in mango at Bengaluru (2013)

Out of 847.5 mm rainfall, 1217.2 mm of water was the required quantity while 711.7 mm of water use was observed during year 2013.

Dapoli

Weather data during the period 1997-2012 was used to develop prediction model for vegetative flush of Alphonso mango. Model developed was tested at various locations of Konkan region.

Veg. flush = 49.466 + 0.440Tmax -0.175 RH-II - 0.033Rainfall – 1.607 Evaporation (R^2= 0.94)

These values are taken 3 weeks prior to vegetative flush stage. The vegetative flush of Alphonso mango was forecasted using various weather parameters at different research station and the results are given in table 4.29. Minimum RMSE was observed at Vengule, followed by Rameshwar.

Table 4. 29: Validation of prediction model developed for predicting vegetative flush in mango

Sr. No.	Location	Weather data used for forecasting (Period)	Forecasted standard meteorological week for vegetative flush	Error (%)	Error (%) for model run up to Forecasted std. Met. Week		
					Avg.	S.D.	RMSE
1.	Dapoli	11^{th} Sept. to 16^{th} Sept., 2013	42^{nd} to 43^{rd} M.W. (15/10/2013 to 28/10/2013)	0.80	13.72	7.91	3.70
2.	Mulde	28^{th} Sept. to 04^{th} Oct., 2013	43^{rd} to 44^{th} M.W. (22/10/2013 to 04/11/2013)	0.36	8.08	4.56	2.84
3.	Vengurle	1^{st} Oct. to 07^{th} Oct., 2013	43^{rd} to 44^{th} M.W. (22/10/2013 to 04/11/2013)	0.48	5.18	3.32	2.28
4.	Rameshwar	28^{th} Sept. to 04^{th} Oct., 2013	43^{rd} to 44^{th} M.W. (22/10/2013 to 04/11/2013)	0.30	5.24	3.47	2.29

A model was developed based on linear multiple regression technique for predicting flowering of Alphonso mango using various weather parameters (Table 4.30).

Table 4.30: Prediction model developed to forecaste of flowering in Alphonso mango in MH

Sr. No.	Regression equation	R^2
	15 days running average weather parameters (before 3 weeks)	
1.	Flowering = - 91.912 + 10.785 Tmax + 6.045 Tmini – 3.397 RH-I + 0.857 RH-II – 5.039 BSS – 3.483 Rainfall – 12.617 Rainy days	0.79*
2.	Flowering = - 41.150 + 8.928 Tmax + 6.136 Tmini – 3.345 RH-I + 0.856 RH-II – 4.623 BSS – 5.086 Rainfall	0.77*
3.	Flowering = - 85.651 + 9.975 Tmax + 6.477 Tmini – 3.669 RH-I + 0.815 RH-II – 3.539 Rainfall	0.75*

The flowering of Alphonso mango was forecasted on the basis of various weather parameters for Konkan region and the results are given in table 4.31. Model-I error percentage was the least, followed by Model-II.

Table 4.31: Validation of prediction model developed for forecasting of flowering in Alphonso mango in MH

Sr. No.	Location	Weather data used for forecasting (Period)	Forecasted standard meteorological week for flowering	Error (%)		
				Model-I	Model-II	Model-III
1.	Dapoli	4^{th} to 18^{th} Dec., 2013	02^{nd} to 4^{th} M.W. (08/01/2014 to 28/01/2014)	1.9	1.3	18.5
2.	Mulde	3^{rd} to 17^{th}, Dec., 2013	50^{th} to 52^{nd} M.W. (10/12/2013 to 31/12/2013)	2.2	7.4	1.4
4.	Rameshwar	3^{rd} to 17^{th}, Dec., 2013)	50^{th} to 52^{nd} M.W. (10/12/2013 to 31/12/2013)	2.2	3.8	4.8

Milk production

Palampur

Effect of weather on milk production was studied for the period 2000-2013. Various weather parameters like rainfall, maximum, minimum and mean temperature, temperature humidity index (THI) values were calculated using THI= Db+0.36*Td+41.5, where Db is dry bulb temperature, td is dew point temperature (^{o}C). The results indicated that THI values during morning varied between 47 to 72 and 58 to 75 during afternoon. The mild heat stress THI (72-79) was observed only in the afternoon (between 12 to 4 pm) during May to September, whereas mornings' of the same months were found to be largely free from heat stress except July. Another important observation is that no heat stress was experienced by the dairy animals below 72 THI (Table 4.32).

Table 4.32: Milk production, concentrates and weather parameters at Palampur (Mean of 2000-2013)

Month	Milk Prod. (L)	Rainfall (mm)	THI I	THI II	Mean THI	TX (^{o}C)	Tn (^{o}C)	Mean Temp. (^{o}C)
Jan	20911.4	86.6	47	58	53	16.1	4.9	10.5
Feb	19507.7	95.8	51	59	55	17.6	6.8	12.2
Mar	22950.2	80.9	57	67	62	22.6	10.6	16.6
Apr	22417.3	45.2	62	70	66	27.3	14.8	21.0
May	24230.8	75.9	68	75	72	30.5	18.3	24.4
Jun	21965.9	248.6	71	75	73	30.2	19.3	24.8
Jul	21527.5	560.3	72	75	73	27.2	19.8	23.5
Aug	20842.7	693.8	71	74	72	26.8	19.3	23.1
Sep	19294.2	260.8	68	74	71	26.4	17.2	21.8
Oct	19175.5	49.1	64	71	67	25.4	13.1	19.3
Nov	18090.5	13.1	54	65	59	21.8	9.3	15.6
Dec	19481.5	27.8	49	60	55	18.6	6.3	12.5

The milk production and minimum temperature and milk production and mean temperature during the months of June, July, August and September were significantly related (milk production vs. minimum temperature, r=0.909, R^2=0.825 and milk production vs. mean temperature, r=0.864, R= 0.750) with each other.

5. Crop Growth Modelling

Crop growth models are being used widely to understand crop responses to environmental / nutrient / water stress. Yield estimation at site specific / regional scales is also being attempted by several researchers. The applicability of exogenous crop growth models for Indian conditions has been studied at various locations and the results of those studies are reported hereunder:

Kharif 2013

AKOLA

Soybean

CROPGRO model (DSSAT v 4.5) was evaluated for simulating soybean crop phenology and productivity at Akola. The genetic coefficients for JS-335, JS 9305 and TAMS 98-21 varieties were generated using the GLUE coefficient estimator embedded in the DSSAT v 4.5 model with experimental data. The model was calibrated within the optimal limits of RMSE (<5%) and D-STAT values to simulate phenology and the observed and simulated values along with statistical evaluation are presented in table 5.1.

Table 5.1: Observed and simulated phenology and yield parameters and their evaluation statistics

Parameter	SIM	OBS	SIM	OBS	SIM	OBS	RMSE			PE (%)			D-stats		
Varieties	JS-335	JS-335	JS 9305	JS 9305	TAMS 98-21	TAMS 98-21	JS-335	JS 9305	TAMS 98-21	JS-335	JS 9305	TAMS 98-21	JS-335	JS 9305	TAMS 98-21
Anthesis day	33	35	35	35	36	39	2.4	1.32	3.08	6.9	3.8	8.0	0.99	0.99	0.99
First pod day	45	48	45	47	47	50	3.1	2.69	3.00	6.4	5.8	6.0	0.99	0.99	0.99
First seed day	54	60	53	59	62	63	5.6	5.27	0.71	9.4	9.0	1.1	0.99	0.99	0.99
Physiological maturity	84	92	84	90	91	97	7.8	6.02	5.87	8.5	6.7	6.1	0.99	0.99	0.99
Straw Yield	1783	2312	1758	2154	2140	2520	543.8	409.0	443.6	23.5	19.0	17.6	0.98	0.99	0.99
Seed yield	1285	1126	1301	1094	1404	1216	163.2	212.1	193.7	14.5	19.4	16.0	0.99	0.99	0.99

On an overall basis model simulation of phenological phases were found to be close the observed. The model predicted the seed yield close to the observed in JS-335 and TAMS-9821. Straw yield was overestimated to a greater degree in JS-335 and to a lesser degree in JS-9305 and TAMS 98-21. Thus, model can be further validated and used for sensitivity analysis for climate change assessment.

ANANTAPUR

Groundnut

Phenological models

Regression models were developed using degree days in groundnut for predicting the number of days required for the occurrence of flowering, pod initiation and maturity stages and validated with observed from the crop sown under rainfed conditions during 2013. It was observed from the model outputs that flowering, pod initiation (< 1 day error) and maturity (3-5 days error) could be predicted within error limits under all dates of sowing (Table 5.2).

Table 5.2: Validation of GDD based phenology prediction functions at Anantapur

Phenological event	Prediction equation	Rainfed	
		Predicted	Actual
Early sowing (09.07.2013)			
Flowering	Y = 0.0604 X – 2.3237	28	28
Pod initiation	Y = 0.0526 X + 3.5424	51	51
Maturity	Y = 0.0353 X + 39.716	108	111
Normal sowing (25.07.2013)			
Flowering	Y = 0.0604 X – 2.3237	25	26
Pod initiation	Y = 0.0526 X + 3.5424	55	56
Maturity	Y = 0.0353 X + 39.716	108	113
Late sowing (17.08.2013)			
Flowering	Y = 0.0479 X + 3.212	24	24
Pod initiation	Y = 0.0495 X + 5.7102	46	46
Maturity	Y = 0.0237 X + 59.227	100	103

Variable X = Growing degree days

Mohanpur

Rice

The DSSAT - Rice model was validated for its accuracy in predicting yield and LAI using the minimum data set developed from the experimental data of Mohanpur center. *Satabdi* variety was transplanted under four different dates (D1-21st June, D2-1st July, D3-16th July and D4-31st July) during the *Kharif*. Grain yields were found to be slightly overestimated (2.5 to 2.7%) by the model under D1 and D3 conditions (Fig. 5.1). For the 1st July transplanting, the model underestimated the yield by 2.2%. But in case of D4, the percent of variation was very high (47%). Crops under D4 were affected by disease and produced unfilled grain which resulted in drastic reduction in yield. This could be the reason behind simulated yield not in tune with the observed yield.

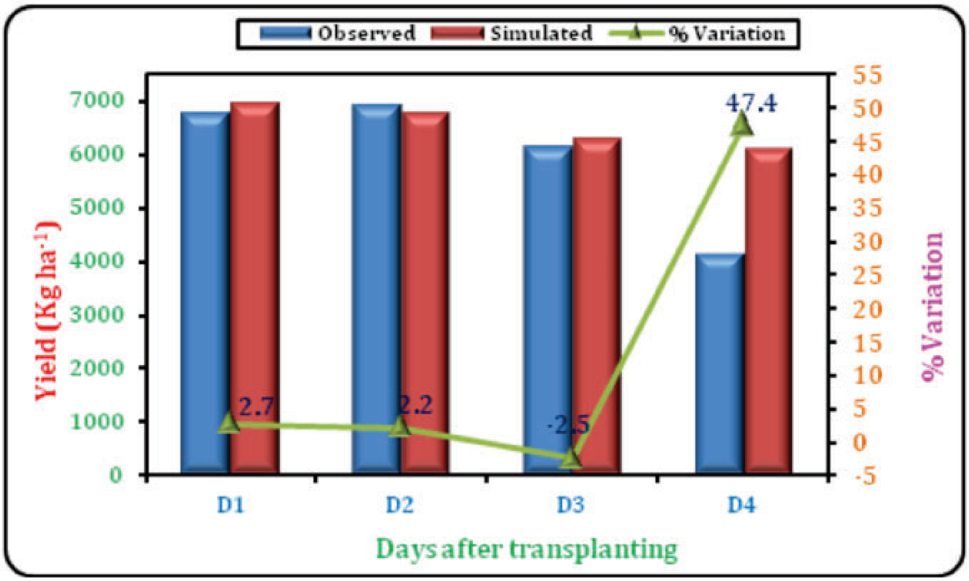


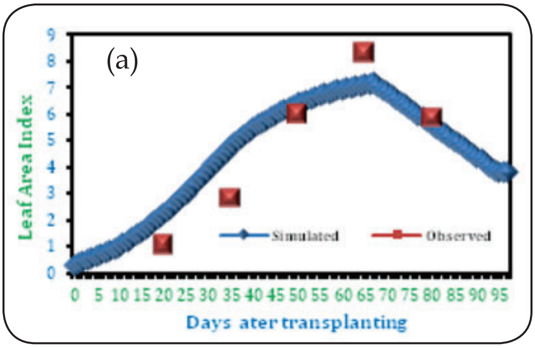
Fig. 5.1: Comparison between observed and simulated Yield

Leaf area index (LAI):

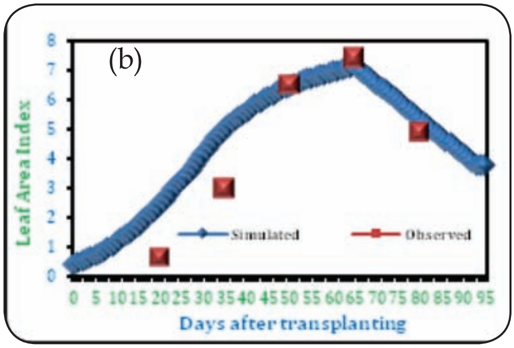
It can been observed from the Fig. 5.2 (a,b,c,&d) that the simulated and observed LAI increased gradually and attained its peak level around 62-67 DAT (except D_3 where the LAI peak observed at 50 DAT in observed) and thereafter decreased at a moderate rate. Highest simulated LAI value (7.15) was under D_1

followed by other dates. But in case of observed, highest LAI (8.3) was attained under D_1 followed by D_3. Further fine tuning of the model is required in simulation of LAI.

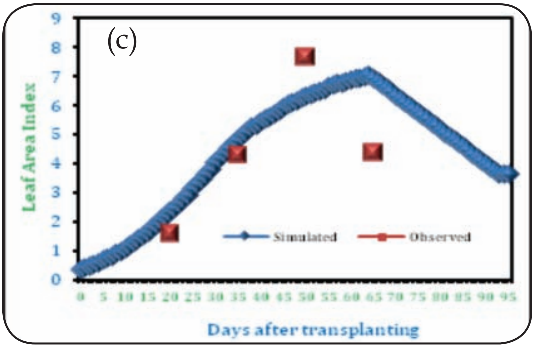
Satabdi



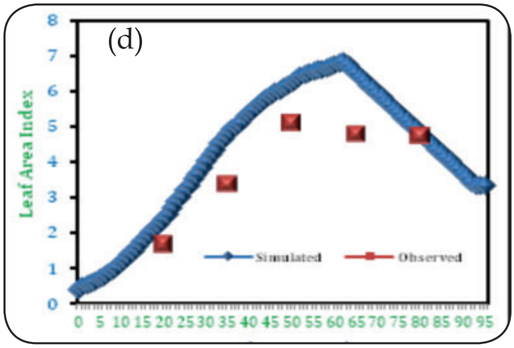
LAI (21st June transplanted)



LAI (1st July transplanted)



LAI (16th July transplanted)



LAI (31st July transplanted)

Fig. 5.2 : (a,b,c,d): Observed and simulated LAI values of Satabdi at different days after transplantation at Mohanpur

Raipur

Rice

The DSSAT-Rice model was used to simulate the rice yields (cv. Karma Mahsuri) at Raipur. Genetic coefficients used in the simulations are presented in table 5.3.

Table 5.3: Genetic coefficients used for DSSAT Rice model at Raipur

Variety	ECO#	P1	P2R	P5	P2O	G1	G2	G3	G4
IB0041-Karma mahsuri	IB0001	690.5	124.8	552.0	9.910	45.51	0.0233	1.00	1.00

The model was evaluated and then simulated the crop phenology and yield and compared with observed data collected during 2013 and the statistical analysis of model performance is given in Table 5.4.

Table 5.4: Statistical analysis of DSSAT Rice model performance at Raipur

Variable Name	Mean		RMSE	d-Stat.
	Observed	Simulated		
Anthesis day	106	98	10.344	0.443
Mat Yield kg/ha	4930	5150	303.29	0.211
Maturity day	136	136	7.371	0.071

Anthesis day was under estimated by the model where as yields were slightly over estimated by 4% . Performance of model in predicting the maturity date is not satisfactory and thus requires future fine tuning.

Rabi

Wheat

Anand

Based on significant association between phase wise weather and grain yield of wheat, step wise regression was carried out for development of an yield prediction model. The models developed are presented in Table 5.5.

Table 5.5: Wheat yield prediction models developed at Anand

Phenophase	Wheat yield prediction model	Model Efficiency
EM	Y = 18618 - 608 (T mean)	R^2= 0.574
CRI	Y = 7651 - 14 (GDD)	R^2= 0.526
TL	Y = 183 (RH_1) - 11798	R^2= 0.464
BT	Y = 144 (RH_1) - 8498	R^2= 0.515
FL	Y = 385.6 (VP Mean) - 56.93	R^2= 0.448
ML	Y = - 9.59 (GDD) + 6407	R^2= 0.627
Dough	Y = 342 (VP_2) +385	R^2= 0.472

Relationship between weather parameters and grain yield under various phases are depicted in Fig. 5.3. Results showed that lower GDD (around 150) for a longer period during milking phase of wheat was found most suitable for higher grain yield. Similarly, morning relative humidity exceeding 90% during booting stage favours higher wheat yield. Tmean around 23 ^{0}C was found optimum during emergence phase for higher grain yields.

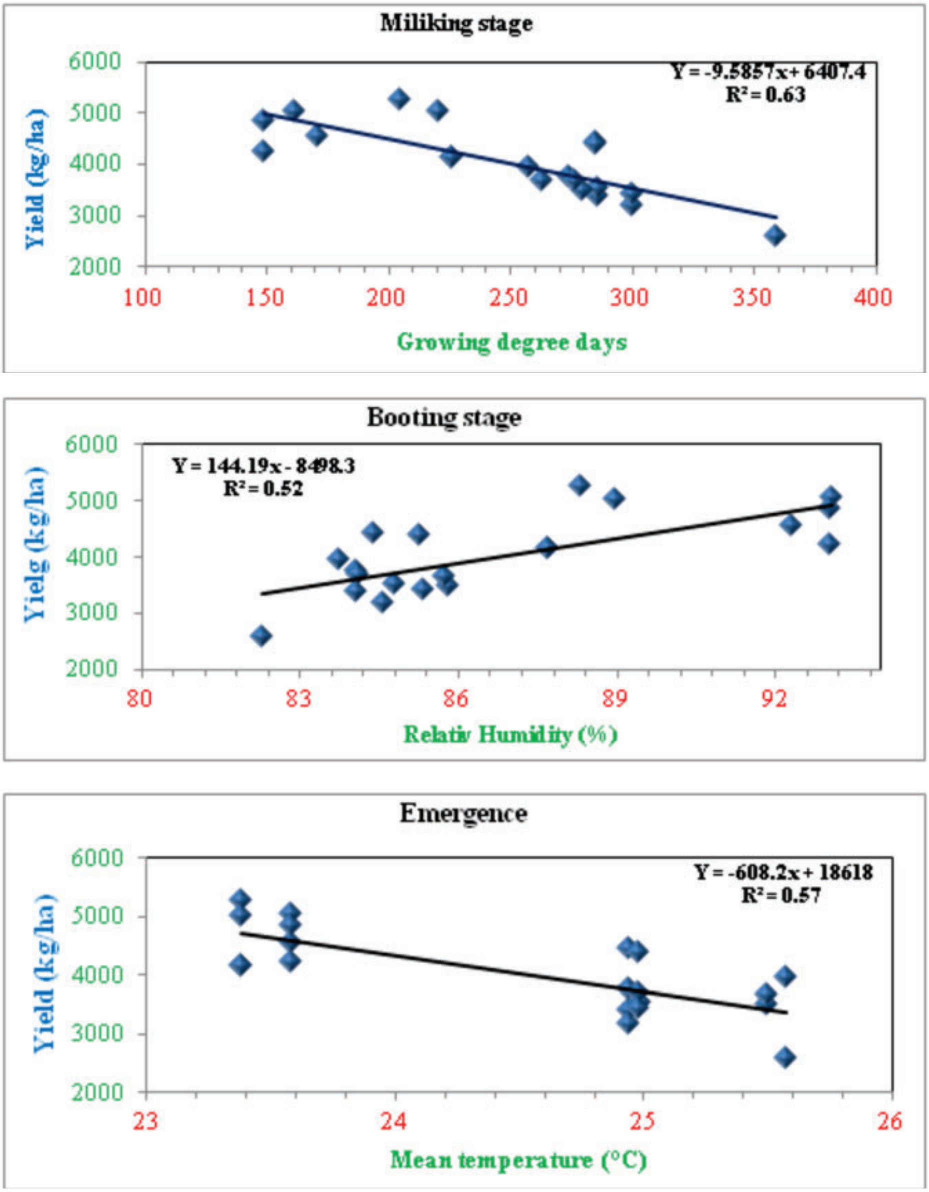


Fig. 5.3: Relationship between weather parameters and grain yield under various phases

6. Effect of weather on pests and diseases

Issue of forewarning on the incidence of various key pests and diseases in field/ orchard crops has considerable economic importance in view of the cost involved in their management through chemical measures. Thus, development of forewarning models for various pests and diseases with sufficient accuracy and lead time is vital. The research efforts made at various centers to develop models for various pests and diseases are presented hereunder:

Rice

Raipur

Five years' experimental data and weather data was used to study the correlation between yellow stem borer incidence and weather parameters and the result is given in Table 6.1.

Table 6.1: Correlation between yellow stem borer with different weather parameters at Raipur

Year	Tmax °C	T min °C	Rainfall (mms)	RH-I (%)	RH-II (%)
2009	-0.11	-0.13	-0.16	0.39*	0.03
2010	-0.14	-0.06	-0.04	0.23	-0.02
2011	0.11	0.04	-0.24	0.05	-0.16
2012	0.03	-0.02	-0.34*	0.13	-0.19
2013	0.05	-0.72**	-0.44**	0.07	-0.71**

The analysis revealed that during 2013, minimum temperature, rainfall and relative humidity during the evening was negatively correlated with yellow stem borer incidence, which was statistically significant.

Groundnut

Bangalore

Multiple leniar regression (MLR) models were developed to predict incidence of tikka disease on three groundnut varieties (TMV-2, JL-24 and K-134), sown on two dates (29 and 32 SMW) employing data on incidence in the previous stage, Growing degree days, rainfall and sunshine hours. Three varieties were raised in *kharif* season from 2005 to 2012 under rainfed conditions. Six years data from 2005-2010 was used for the development of the prediction model based on SSH, GDD, RF and incidence in the previous stage. MLR models based on 9 varieties (Varietal and stage specific) and three general models (Irrespective of varieties, but stage specific) were developed. Coefficient of MLR model, its adjusted R^2, ANOVA F value and its significance are presented in Table 6.2.

Table 6.2: Results of MLR, t-test and ANOVA

Variety / Stages	Intercept	GDD	RF	SSH	Tikka %	ANOVA (F)	Adjusted R^2
80 days	44.12*** (10.51)	-0.247*** (0.068)	0.118** (0.047)	0.260*** (0.076)	1.476*** (0.381)	12.38***	0.565
V1 – 80 days	57.46*** (14.33)	-0.241** (0.087)	0.118* (0.059)	0.078 NS (0.104)	3.637*** (0.834)	8.20***	0.723
V2 – 80 days	48.62** (18.57)	-0.316** (0.129)	0.185* (0.092)	0.342** (0.142)	0.935* (0.50)	4.54**	0.563
V3 – 80 days	40.71 NS (23.30)	-0.230 NS (0.151)	0.068 NS (0.105)	0.275 NS (0.167)	1.954* (0.946)	3.465*	0.472
90 days	91.05*** (18.905)	0.084 NS (0.118)	0.088 NS (0.171)	-0.345 NS (0.208)	-0.613 NS (0.489)	1.047 NS	0.011
V1 – 90 days	121.79** (2.576)	-1.024** (0.038)	0.680** (0.030)	0.894** (0.031)	0.152 NS (0.040)	207.22*	0.993
V2 – 90 days	70.44 NS (12.81)	-0.091 NS (0.169)	-0.05 NS (0.126)	0.157 NS (0.147)	0.194 (0.159)	3.913 NS	0.699
V3 – 90 days	79.72 NS (15.64)	-0.558 NS (0.227)	0.400 NS (0.172)	0.542 NS (0.193)	0.285 NS (0.158)	2.636 NS	0.567
Harvest	57.09*** (10.59)	-0.185** (0.066)	0.010 NS (0.096)	0.187 NS (0.117)	0.525* (0.274)	53.73***	0.925
V1 – Harvest	65.76 NS (32.62)	-0.328 NS (0.246)	0.164 NS (0.277)	0.375 NS (0.389)	0.351 NS (0.782)	8.270 NS	0.453
V2 – Harvest	80.64 NS (16.9)	0.096 NS (0.157)	0.283 NS (0.353)	-0.702 NS (0.632)	-0.572 NS (0.672)	2.566 NS	0.280
V3 – Harvest	62.11 NS (57.12)	-0.218 NS (0.261)	0.079 NS (0.377)	0.175 NS (0.497)	0.435 NS (1.63)	4.585 NS	0.341

The models were validated with the experimental results of 2013 (Table 6.3). The analysis indicated that the models predicted tikka incidence more accurately during harvest time, followed by 90 DAS. The economic viability of any prophylactic measure is governed by the time of interpretation of the disease and the extent of yield damage it causes. In such context, the utility of predicting the tikka disease during maturity has to be assessed from further studies.

Table 6.3: Validation of weather based multiple linear regression models of Tikka disease incidence (%) over different stages and varieties using 2013 experimental data

Particulars		29 SMW			32 SMW			Combined		
		Pre-dicted	Ob-served	Devia-tion	Pre-dicted	Ob-served	Devia-tion	Pre-dicted	Ob-served	Devia-tion
Com-bined	**80**	10.3	35.2	**-70.8**	11.5	33.9	**-66.3**	10.9	34.6	**-68.6**
	90	57.6	66.2	**-12.9**	51.6	69.2	**-25.4**	54.6	67.7	**-19.3**
	Harvest	83.8	84.4	**-0.7**	94.9	86.8	**9.4**	89.4	85.6	**4.4**
V-1	**80**	9.6	37.8	**-74.7**	8.4	29.2	**-71.2**	9.0	33.5	**-73.2**
	90	52.7	71.1	**-25.9**	55.3	66.2	**-16.5**	73.2	68.7	**6.6**
	Harvest	72.9	82.0	**-11.1**	79.8	85.5	**-6.7**	76.4	83.8	**-8.8**
V-2	**80**	8.4	34.2	**-75.5**	10.1	32.9	**-69.2**	9.3	33.5	**-72.3**
	90	64.1	65.7	**-2.5**	67.5	74.3	**-9.1**	65.8	70.0	**-6.0**
	Harvest	75.5	85.0	**-11.1**	115.9	86.5	**34.0**	85.1	85.8	**-0.8**
V-3	**80**	9.3	33.6	**-72.4**	10.7	39.7	**-73.1**	10.0	36.7	**-72.8**
	90	59.8	61.7	**-3.1**	70.8	67.2	**5.4**	65.3	64.4	**1.3**
	Harvest	70.0	86.3	**-18.8**	80.2	88.3	**-9.1**	75.1	87.3	**-13.9**

Safflower

Akola

Effect of weather parameters on aphid infestation in sunflower (c.v. Bhima), sown on three dates (40, 41 and 42 SMW) was studied. Observations on the sunflower aphid population were taken from 10 cm apical twig, at weekly interval from five randomly selected plants in each plot. Correlation coefficients between aphids population and weather parameters with different lag periods (0, 1, 2 and 3 weeks) of peak aphid incidence were worked out (Table 6.4).

Table 6.4: Correlation between aphids and weather parameters with differnet lead periods in safflower

Parameters	Lead time (Weeks)			
	0	1	2	3
Max.T.	-0.596**	-0.557**	-0.285	-0.222
Min.T.	-0.346*	-0.464**	-0.528*	-0.597**
RH_I	0.533**	0.469**	0.270	0.080
RH_{II}	0.132	-0.014	-0.366**	-0.596**
RF	-0.027	-0.077	-0.321*	-0.376*
WS	-0.468**	-0.517**	-0.637**	-0.512**
BSH	-0.231	-0.095	0.226	0.281

Maximum and minimum temperatures at lag phase 0, 1, 2 and 3 showed significant negative correlation with aphid incidence. Morning relative humidity showed positive correlation during 0 and 1 lag phases. Regression of aphid population on weather parameters strengthened the observation (Fig. 6.1). This indicates that low Tmax and high morning relative humidity conditions are congenial for aphid population in safflower crop.

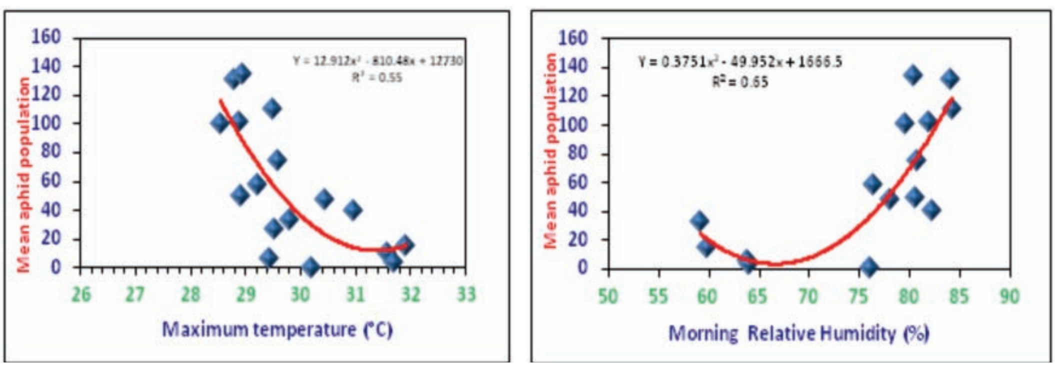


Fig. 6.1: Relationship of Tmax and morning RH with sunflower aphid incidence

Lower maximum temperature of around 29.0 °C and morning relative humidity of 80 to 85 per cent were found to be congenial for aphids population in safflower.

Solapur

Development of weather based forewarning model for *Alternaria* leaf spot of safflower was attempted for the scarcity zone of Maharashtra. Linear regression models were developed for predicting diseases incidence for early, normal and late sown conditions of the crop. Weather data and data on disease incidence during 2003-04 to 2012-13 were used for the development of the model. Linear regression equations thus developed are given in table 6.5.

Table 6.5: Linear Regression equations for Alternaria leaf spot of safflower under three sowing situations

Sowing situation	Multiple linear regression equation	R^2 value
Early	PDI= 104.28-6.72*T_{min}+2.19*RH-I-1.81*RH-II-0.37*RF	0.92
Normal	PDI= 440.91-7.97*T_{max}-1.17*T_{min}-1.67*RH-I	0.95
Late	PDI= 295.03-6.23*T_{max}-1.23*T_{min}-0.729*RH-I	0.94

The equations developed were validated with the disease data of the year 2013-14 for predicting the incidence of Alternaria leaf spot of safflower under different sowing situations. Observed and predicted values of PDI of Alternaria leaf spot of safflower (Table 6.6) were compared and statistically analyzed with Chi-square test for goodness of fit. The calculated $\chi 2$ was less than tabular value $\chi 2$ for early, normal and late sowing situations for the linear models (Table 6.7). Hence the equations can be used for prediction. Hence, this model can be utilized in Agro-Advisories for prediction of Alternaria leaf spot in safflower.

Table 6.6: Observed and predicted PDI of Alternaria leaf spot of safflower under three sowing situations using linear regression equations for the year 2013-14.

Time interval (7 days)	Percent Disease Index (PDI)								
	Early			Normal			Late		
	Observed	Predicted	Deviation	Observed	Predicted	Deviation	Observed	Predicted	Deviation
1	12.80	24.2	-11.4	12.2	12.99	-0.79	10.0	2.8	7.2
2	22.10	26.3	-4.2	19.3	14.74	4.56	18.9	4.1	14.8
3	30.30	52.0	-21.7	23.4	11.34	12.06	23.3	15.0	8.3

Time interval (7 days)	Percent Disease Index (PDI)								
	Early			Normal			Late		
	Observed	Predict-ed	Devia-tion	Ob-served	Pre-dicted	Deviation	Ob-served	Predicted	Devia-tion
4	37.80	45.2	-7.4	31.9	14.68	17.22	24.9	10.8	14.1
5	43.70	53.3	-9.6	45.9	26.83	19.07	24.9	20.6	4.3
6	52.22	73.5	-21.28	59.4	25.17	34.23	24.9	34.5	-9.6
7	76.67	59.1	17.57	61.3	36.75	24.55	24.9	17.6	7.3
8	82.22	75.3	6.92	61.3	58.44	2.86	24.9	15.4	9.5
9	82.22	95.9	-13.68	61.3	35.38	25.92	24.9	28.2	-3.3
10	82.22	96.2	-13.98	69.9	30.23	39.67	24.9	33.9	-9
11	82.22	98.7	-16.48	69.9	45.49	24.41	24.9	38.4	-13.5
12				69.9	56.49	13.41	24.9	32.2	-7.3
13				69.9	64.12	5.78	24.9	32.8	-7.9

Table 6.7: Chi-square (χ^2) test for goodness of fit for linear model

1.	**Early sowing:**	
		Cal χ^2 = 5.180
		Tab χ^2 for 0.05 level of significance and 10 d.f. = 19.675
2.	**Normal sowing:**	
		Cal χ^2 = 2.689
		Tab χ^2 for 0.05 level of significance and 12 d.f. = 21.026
3.	**Late sowing:**	
		Cal χ^2 = 3.886
		Tab χ^2 for 0.05 level of significance and 12 d.f. = 19.675

Forewarning model for safflower aphid

Linear regression equations were developed based on ten years' (2002-03 to 2011-12) data on weather and disease incidence for predicting safflower aphid incidence for two varieties under normal sown conditions. The equations developed are:

1) APH= 1002.17 -29.70*T_{max}-13.49*T_{min} +4.64*RH-II for normal sown C.v. A-1

2) APH= 1333.54 -44.33*T_{max}-22.08*T_{min} +11.90*RH-II for normal sown C.v. CO-1

where, APH is the aphid population

These equations were validated using disease incidence data of 2013-14 and the results are given in table 6.8.

Table 6.8: Observed and predicted aphid incidence by using linear regressionequations (2013-14).

SMW	Aphid population/5 cm apical twig/plant							
	A-1				Normal CO-1			
	Ob-served	Pre-dicted	Deviation/ Residuals	Standard-ized re-sidual	Ob-served	Predicted	Deviation/ Residuals	Standardized residual
45-46	20	39	-19	-1.4	59	69	-10	-1.0
46-47	62	67	-5	-0.7	74	77	-3	-0.6
47-48	48	16	32	1.2	52	13	39	1.9
48-49	50	34	16	0.4	102	93	9	0.2
49-50	63	45	18	0.5	72	69	3	-0.2
50-51	58	19	39	1.6	64	55	9	0.2
51-52	97	75	22	0.7	88	71	17	0.6
52-1	122	111	11	0.1	146	162	-16	-1.4
1-2	85	66	19	0.5	70	80	-10	-1.0
2-3	20	7	13	0.2	38	6	32	1.5
3-4	13	11	2	-0.3	24	2	22	0.9
4-5	24	50	-26	-1.7	51	55	-4	-0.6
5-6	34	49	-15	-1.2	40	43	-3	-0.6

(Standard Residual > 3 is outlier)

The standardized residual values estimated based on deviation between observed and predicted aphids are less than 3.00 which indicated the suitability of models for aphid prediction. Chi-square test was also employed, which indicated that there were no significant differences between predicted and observed aphids, hence the regression equations are good fit.

Wheat

Hisar

Multiple regression models were developed for predicting Karnal bunt incidence in wheat for Karnal, Rewari, Hisar and Sirsa regions of Haryana by using selected meteorological parameters during 6-12 SMW. These equations are given below:

Karnal: $Y = -0.282+0.042\,RD_6+0.028Tmin_8+0.023RD_8+0.002Tmin_9+0.001RF_9+0.072RD_{11}$ ($R^2 = 0.68$)

Rewari: $Y = 0.921+0.039Tmax_6+0.255RD_6 - 0.005RF_9 - 0.061\,Tmax_{10} - 0.022RF_{11} +0.630RD_{11}$ ($R^2 = 0.92$)

Hisar: $Y = 0.024+0.038RF_5 - 0.100RD_5+0.012RF_{11} - 0.041RD_{11}+0.099RD_{12}$ ($R^2 = 0.79$)

Sirsa: $Y = 0.596+0.051RD_6+0.105RD_{10} -0.020\,Tmax_{11} +0.021RF_{11} -0.149RD_{11}$
($R^2 = 0.92$),

where, RD - rainy days and the number given as subscript is SMW. These models were validated with 2012-13 and 2013-14 experimental data and the results are given in table 6.9.

Table 6.9: Observed and predicted Karnal bunt disease by different regression models for Haryana state

Year	Karnal		Hisar		Rewari		Sirsa	
	P	O	P	O	P	O	P	O
2012-13	0.207	0.164	0.359	0.484	0.256	0.242	0.072	0.068
2013-14	0.132	-	0.187	-	0.324	-	0.062	-

The models performed well at all the locations, allowing less deviation in predicted from observed values.

Mustard

Anand

Effect of weather parameters on aphid infestation in mustard variety GM-2, sown on four dates (10, 20, 30 Oct and 10 Nov 2013) was studied. The relationship between peak aphid intensity and weather parameters prevailed at that time was investigated and depicted in Fig. 6.2.

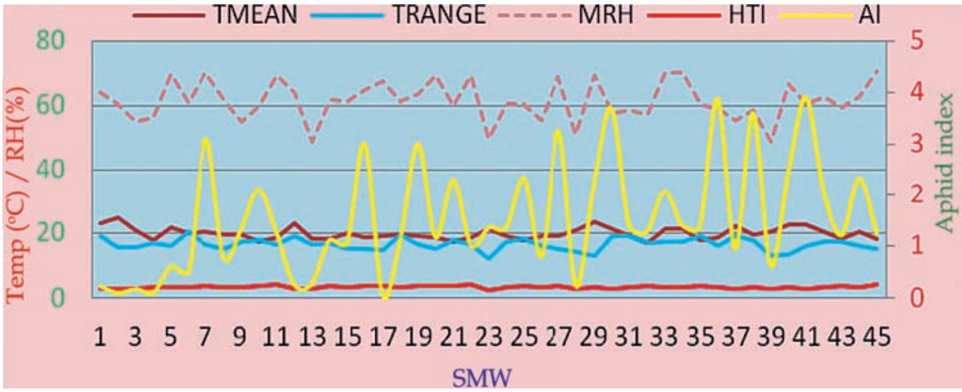


Fig. 6.2: Relationship between peak aphid intensity and weather parameters in mustard at Anand

The figure 6.2 indicates that peak aphid infestation occurs under a particular range of weather parameters. Tmean (19-25.5 ^{0}C), Trange (14-19 ^{0}C), Mean RH (53-70 %) and THI (2-3) were found most congenial weather range for peak aphid initiation at Anand.

Potato

Mohanpur

Influence of weather parameters on incidence of late blight of potato was investigated. Tmax, Tmin, rainfall, RH-I & II was used in the study and percentage disease incidence (PDI) was recorded following standard procedure. Joyati variety was sown on three dates (Nov 15, 29 and Dec 13, 2013). The result of the analysis is given in fig. 6.3, 6.4 and 6.5.

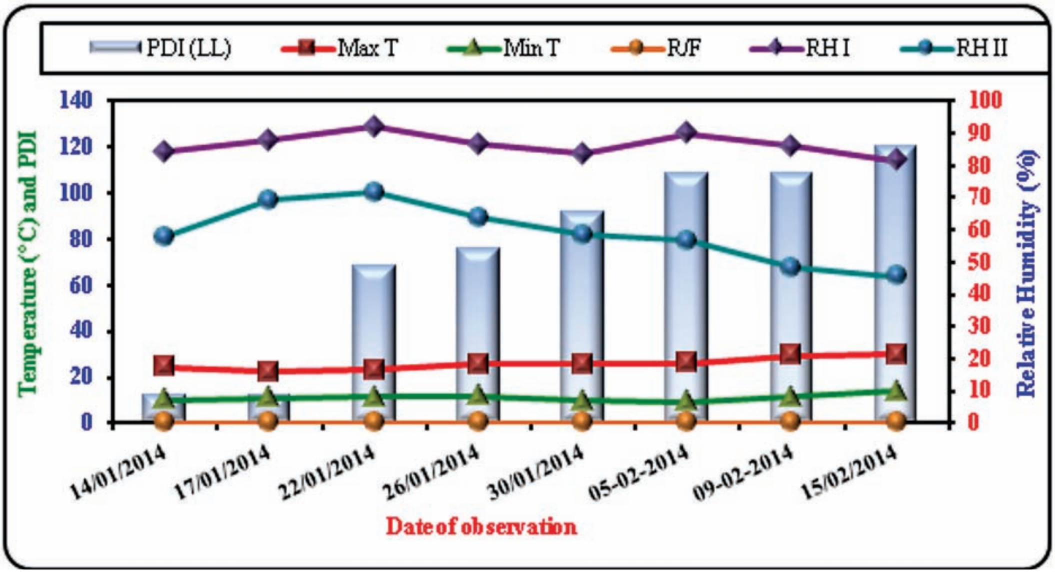


Fig. 6.3: Association between potato late blight (C.v. Joyati) and weather conditions (Temperature and RH) for first date of sowing (D-1)

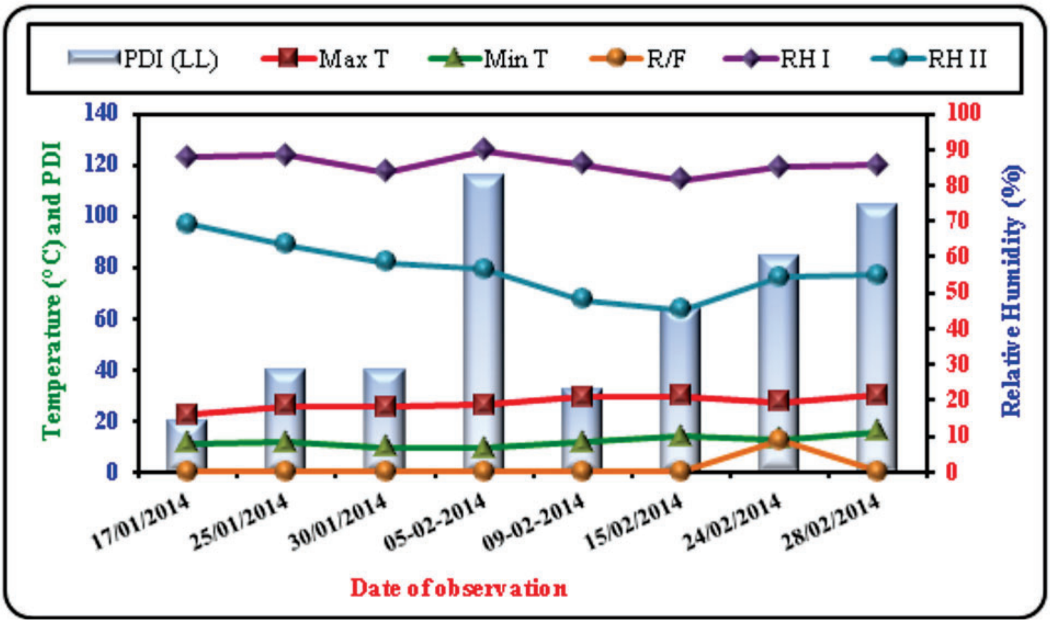


Fig. 6.4: Association between potato late blight (C.v. Joyati) and weather conditions (Temperature and RH) for second date of sowing (D-2)

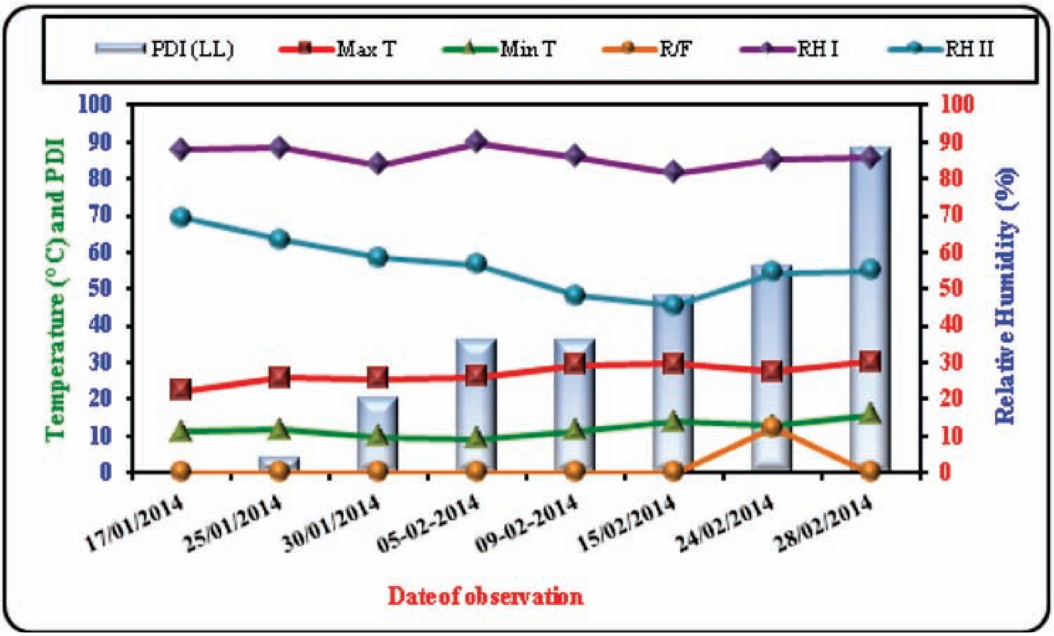


Fig. 6.5: Association between potato late blight (C.v. Joyati) and weather conditions (Temperature and RH) for third date of sowing (D-3)

In all the three cases, it was observed that higher PDI was associated with high temperature range. For crop sown on Nov 29 and Dec 13, rainfall occurred during last fortnight of February and this has caused high RH-I and II, which in turn provided congenial weather for high incidence of the late blight.

7. Summary

Agroclimatic characterization

- Meteorological drought analysis carried out using SPI for Eastern, Western and Central Vidarbha zones indicated that August precipitation has increased for the past 112 years in Eastern and Central zones.
- Trend analysis of maximum temperature during 1959-2009 for Godhra district of Gujarat showed significantly increasing trend for winter (0.03°C/year), monsoon (0.016 °C/year), post-monsoon (0.039 °C/year) and on annual (0.027 °C/year) time scales.
- Ideal crop growing period for Bangalore was identified as 28-44 standard meteorological weeks using rainfall probability analysis.
- Analysis of meteorological drought climatology of Bijapur district of Karnataka revealed that the incidence of moderate drought years was more during the period 1961-90.
- Extreme event analysis using 'RClimdex 1.1' for Upper Brahmaputra Valley Agroclimatic Zone (UBVZ) of Assam indicated that Dibrugarh has experienced more intense rainfall events, where as its number of rainy days have decreased during the last 30 years.
- Length of Growing Period (LGP) analysis carried out for Southern agroclimatic zone of Tamil Nadu showed that LGP ranged from 7-45 SMW with an average of 12 weeks.
- Analysis of weather data during 1985-2013 revealed that hail storm events (0.18 per year) and dew days (3 per year) increased at Palampur.
- Changes in quantum of rainfall received on seasonal and annual basis during 1991-2013 was compared against the base period (1961-1990) for Chhattisgarh. Most of the districts showed negative departure of SW monsoon and it decreased by 20.8 per cent in Raigarh and by about 11.4 per cent rainfall in Rajnandgaon.
- Analysis of variation in LGP for coarse, medium and fine textured soils revealed that growing period is showing a decreasing trend in all types of soils in Darbhanga, Hayaghat and Jale districts of Bihar.

Crop-weather relationships

Kharif 2013

Rice

- Rice varieties Karjat-2 and Swarna recorded highest HTU of 6818, 7329, 8118, when sown on 23, 24 and 25 SMW, respectively, at Dapoli.
- Sarjoo-52 showed highest RUE at all stages of crop growth, followed by NDR 359 at Faizabad.

Maize

- Maize cultivars HQPM-1 and BIO-9637 recorded highest grain yield acrosss three sowing windows at Udaipur.

Pearlmillet

- Among different varieties, ICTP-8203 recorded highest consumptive use of moisture (CUM) and moisture use efficiency (MUE) compared to Mahyco and Shanti at Solapur.

Pigeonpea

- Rainfall, vapor pressure and humidity along with minimum temperature showed highly significant positive correlation, whereas temperature range and sunshine parameters showed highly significant positive correlation with yield during pod formation and grain filling stage at Bijapur.

Soybean

- Variety TAMS-98-21 showed highest crop water use, water use efficiency (WUE) and water productivity (WP) than JS-335 and JS-9305 when sown during four sowing windows (26,27,28 and 29 SMW) at Akola.
- Humidity parameters and soil moisture, except humidity range showed highly significant positive association during grain development stage at Parbhani.

Sunflower

- Optimum moisture use efficiency (MUE) for attaining higher grain yield was found to be 3.50 to 4.00 kg ha/mm at Solapur.

Cotton

- Among different adaptation strategies used for increasing WUE, dead mulch showed highest WUE and WP (1.82 and 2.92 kg ha-mm^{-1}), followed by conservation furrows at Akola.

Rabi 2013-14

Wheat

- Temperature showed significant negative association during emergence to crown root initiation phase with grain yield at Anand.
- Correlation studies between weather parameters with grain yield at Hisar revealed that maximum and minimum temperatures were positively correlated with seed yield during vegetative stage and negatively during reproductive stage.
- Heat use efficiency (HUE) estimation indicated that variety Kanchan recorded highest HUE (average HUE of 0.44 g/m^2 deg day across five sowing dates) followed by GW-273.
- A mean temperature of 15.2 to 18.3 °C and 18.5 to 21.2 °C during heading to milking stage and during milking to dough stage, respectively was found conducive for getting higher grain yield of wheat at Udaipur.

Chickpea

- Cultivar SAKI-9516 recorded highest HUE both in terms of grain yield and biomass, followed by Vijay at Akola.
- In Anantapur, it was observed that the pod set on the day of fog occurrence was low in crop grown in control plots for all *desi* varieties.

Mustard

- Correlation studies of weather parameters with grain yield at Hisar revealed that seed yield and yield attributes were significantly and positively correlated with minimum temperature and sunshine hours during vegetative phase but negatively correlated with the same weather parameters at reproductive phase.
- Among the varieties, NRCDR-2 recorded highest HUE over NPJ-112 when sown under three sowing times (Oct 17, 27 and Nov 6, 2013) at Jammu.

Tea

- Optimum minimum and maximum temperatures for the growth of tea bush were found to be between 8.5-20.5 and 21.5-31.5 °C, respectively at Palampur.

Mango

- Models based on linear regression technique were developed for predicting vegetative flush and flowering at Dapoli.

Crop growth modeling

- Soybean model (DSSAT v 4.5) was evaluated for three varieties JS-335, JS 9305 and TAMS 98-21 at Akola and its performance in respect of phenological phases and seed yield is reliable.
- Calibration and validation of rice c.v. Karma Mahsuri and Satabdi are in progress at Raipur and Mohanpur respectively. A minimum data set for rice variety Vandana was prepared at Ranchi.
- Regression based models were developed using duration of phenological stages and GDD and were evaluated with observed values. The models predicted flowering, pod initiation (< 1 day error) and maturity (3-5 days error) accurately under all dates of sowing.

Effect of weather on pests and diseases

Rice

- Correlation analysis between yellow stem borer incidence and weather parameters at Raipur revealed that during 2013, minimum temperature, rainfall and afternoon relative humidity were negatively correlated with yellow stem borer incidence, which was statistically significant.

Safflower

- Low maximum temperature and high morning relative humidity conditions were found to be congenial for aphid population build up in safflower at Akola.
- Weather based linear regression models for Alternaria leaf spot of safflower was developed at Solapur.

Wheat

- Multiple regression models were developed for predicting Karnal bunt incidence in wheat for Karnal, Rewari, Hisar and Sirsa regions of Haryana by using selected meteorological parameters during 6-12 SMW.

Mustard

- Mean temperature of 19-25.5 °C, temperature range of 14-19 °C, Mean RH (53-70 %) and THI (2-3) were found most congenial weather conditions for peak aphid attainment at Anand.

Research Publications: 2013-14

Co-ordinating Unit

International Journals

Bapuji Rao, B., Santhibhushan Chowdary, P., Sandeep, V. M., Rao, V. U. M and Venkateswarlu, B. (2014). Rising minimum temperature trends over India in recent decades: Implications for agricultural production. Global Planet. Change., 117: 1-8.

Bapuji Rao, B., Santhibhushan Chowdary, P., Sandeep, V. M., Promod, V.P., and Rao, V. U. M. (2014). Spacial analysis of the sencitivity of wheat yield to temperature in India. Agricultural and Forest Meteorology, DOI: 10.1016/j.agrformet.2014.09.23.

Bapuji Rao, B., Rao, V. U. M., Linitha Nair., Prasad, Y. G., Ramaraj, A. P and Chattopadhyay, C. (2013). Assessing aphid infestation in Indian mustard (brassica Juncea l.) Under present and future climate scenarios. Bangladesh J. Agril. Res., 38(3): 373-387.

Saxena, K. K., Lokesh Ruhual and Rao, V. U. M. (2013). Akaike's information criterion for order identification of daily rainfall at Hisar. Int. J. Agric. Stat. Sci., 9(1):71-78.

Vijaya Kumar, P., Bindi, M., Crisci, A and Maracchi, G. (2013). Detection of variations in precipitation at different time scales of twentieth century at three locations of Italy, Weather and Climate Extremes. 2: 7-15.

Vijaya Kumar, P. (2014). Development of weather-based prediction models for leaf rust in wheat in the Indo-Gangetic plains of India. Eur. J. Plant Pathol., DOI 10.1007/ 10658-014-0478-6.

Indian Journals

Bapuji Rao, B., Rao, V. U. M., Linitha Nair., Prasad, Y. G., Ramaraj, A. P and Chattopadhyay, C. (2013). Mustard aphid infestation in India: Development of forewarning models. J. Environ. Biol., 35:

Desai, S., Prabhakar, M., Prasad, Y. G., Srinivasa Rao, M., Ravi Kumar, N and Rao, V. U. M. (2013). Understanding the relationship between groundnut canopy level weather and observatory weather for leafspot disease prediction. J. Agrometeorol., 15(Special Issue-II): 115-119.

Jena, S., Bandopadhyay, P., Ranath., Mukherjee, A., Rao, V. U. M and Chakraborty, P. K. (2013). Effect of leaf temperature on Alternaira blight in wheat-mustard intercropping system. J. Agrometeorol., 15(Special Issue-II): 159-161.

Jugal, K. M., Raj Singh., Diwan Singh and Rao, V. U. M. (2013). Variation in radiation use efficiency of wheat (Triticum aestivum L.) as influenced by thermal stress management strategies under late sown conditions. J. Agrometeorol., 15(Special Issue-II): 138-141.

Khushu, M. K., Charu Sharma., Sanjay Koushal., Rajeev Sharma., Bapuji Rao, B and Rao, V. U. M. (2013). Simulation of phenology, growth and yield of maize cultivar using CERES-Maize model. J. Agrometeorol., 15(Special Issue-II): 222-226.

Nagasree, K., Ravi Shankar, K., Venkateswarlu, B., Dixit, S., Raju, B. M. K., Rao, A. V. M. S and Vijay Jesudasan. (2013). An analysis on use of ICT tools for dissemination of weather based agro advisories. J. Agrometeorol., 15(Special Issue-II): 110-115.

Pratyusha Kranthi., Rao, K. V., Prasad, J. V. N. S., Rajbir Singh and Rao, V. U. M. (2013). Spatial and temporal assessment of net primary productivity for Andhra Pradesh using MODIS data. J. Agrometeorol., 15(Special Issue-II): 188-193.

Rajkumar Dhakar., Sehgal., V. K., Shivani Nagar., Rao, V. U. M., Bapuji Rao, B., Vijaya Kumar, P., Rao, A. V. M. S and Ravi Dupdal. 2013. Impact of drought on spatio-temporal pattern of phenology in Rajasthan. J. Agrometeorol., 15 (Special Issue-II): 58-63.

Raju, B. M. K., Rao, K.V., Venkateswarlu, B., Rao, A. V. M. S., Rama Rao, C. A., Rao, V. U. M., Srinivasa Rao, M and Nagasree, K. (2013). Change in climate in India during last few decades. J. Agrometeorol., 15(Special Issue-I): 30-36.

Raju, B. M. K., Rao, K.V., Venkateswarlu, B., Rao, A. V. M. S., Rama Rao, C. A., Rao, V. U. M., Bapuji Rao, B., Ravi Kumar, N., Dhakar, R., Swapna, N and Latha, P. (2013). Revisiting climatic classification in India: a district-level analysis. Curr. Sci. India. 105(4): 492-495.

Rao, A. V. M. S., Jaypal, M., Rao, V. U. M., Narsimha Rao, V and Raju, N. S. (2013). Mandal-wise analysis of dry spell probability during different growth stages of rice in Medak district of Andhra Pradesh. J. Agrometeorol., 15(Special Issue-II): 73-79.

Rao, V. U. M and Bapuji Rao, B. (2013). Climate change impact on Indian agriculture - Adaptation and mitigation strategies. J. Res. Punjab Agric. Univ. 50(3&4): 82-91.

Saikia, U. S., Goswami, B., Rajkhowa, D. J., Venkatesh, A., Kausalya Ramachandran., Rao, V. U. M., Venkateswarlu, B and S. V. Ngachan. (2013). Shift in monsoon rainfall pattern in the North Eastern region of India post 1991*. J. Agrometeorol., 15(Special Issue-II): 162-164.

Vijaya Kumar, P., Rao, V. U. M., Bhavani, O., Dubey., A. P., Sidhu, P. K., Patel, S. R and Venkateswarlu, B. (2013). Optimizing sowing dates and selection of varieties of wheat through long-term crop and weather analysis. J. Agrometeorol., 15 (Special Issue-II): 67-72.

Papers presented in National and International Symposia / Seminars

Janahiraman, V., Babu, R., Solaimalai, A., Jawahar, D and Rao, V. U. M. (2013). Long term weather analysis of Madurai Station of Tamil Nadu. In: Proc. of National Symposium on "Climate change and Indian Agriculture: Slicing Down the Uncertainties" held at CRIDA, Hyderabad, January 22 & 23, 2013. P: 27.

Patel, G. G., Patel, H. R., Pandey, V., Yadav, S. B and Rao, V. U. M. (2013). Weather based forewarning models for mustard aphid under middle Gujarat agro climatic condition. In: Proc. of National Symposium on "Climate change and Indian Agriculture: Slicing Down the Uncertainties" held at CRIDA, Hyderabad during 22-23 January 2013, pp 228.

Patel, H. R., Lunagaria, M. M., Karande, B. I., Vyas Pandey., Shah, A. V., Rao, V. U. M and Naresh Kumar. (2013). Impact of projected climate change on groundnut in Gujarat. In: Proc. of National symposium on "Climate change and Indian Agriculture: Slicing Down the Uncertainties" held at CRIDA, Hyderabad during 22-23 January 2013, pp 97.

Rajkumar Dhakar., Sehgal, V. K., Rao, V. U. M., Bapuji Rao, B., Vijaya Kumar, P., Rao, A. V. M. S and Ravi Dupdal. (2013). Impact of drought on spatio-temporal pattern of phenology in Rajasthan. In: Proc. of National Symposium on " Climate change and Indian Agriculture: Slicing Down the Uncertainties " held during 22-23 January 2013 at CRIDA, Hyderabad.

Raju, B. M. K., Rama Rao, C. A., Rao, K. V., Rao, A. V. M. S., Venkateswarlu, B., Maruthi Sankar, G. R and Swapna N. (2013). Identification of sources of productivity growth in sorghum – A multivariate clustering approach. In: 67th Annual Conference of Indian Society of Agricultural Statistics, December 18-20, 2013. Department of Farm Engineering, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi.

Raju, B. M. K., Rama Rao, C. A., Rao, K.V., Venkateswarlu, B., Josily Samuel., Ravi Dupdal., Rao, A. V. M. S., Maruthi Sankar, G. R., Md Osman., Ravi Shankar, K., Gopinath, K. A., Srinivasa Rao, M and Swapna, N. (2014). Unreaped yield potential in cotton in India. In: 2nd International Conference on Agricultural & Horticultural Sciences. Agrotechnology 2014. OMICS Group Conferences. February 3-5, 2014. Vol.2, Issue 4. http://dx/doi.org/ 10.417/2-168/9881.S1.007.

Rama Rao, C. A., Raju, B. M. K., Josily Samuel., Ravi Dupdal., Yella Reddy, D., Rao, A. V. M. S., Rao, V. U. M and Venkateswarlu, B. (2013). Vulnerability of pigeon pea yields to climate change in India A panel data of regression approach. In: International Conference on Climate Change and Sustainable Development Global Perspective. February 20-21, IPE, Institute of Public Enterprise, Hyderabad. 5-6.

Rama Rao, C. A., Raju, B. M. K., Rao, A. V. M. S., Rao, K. V., Rao, V. U. M., Kausalya Ramachandran., Venkateswarlu, B and Sikka, A. K. (2014) Assessment of Vulnerability Indian Agriculture to Climate Change. In: National Seminar on "Climate Change – Crop Improvement and Management Strategies for Food Security on 25 March 2014 at Agricultural College, Bapatla.

Rama Rao, C. A., Raju, B. M. K., Josily Samuel., Ravi Dupdal., Yella Reddy, D., Rao, A. V. M. S., Rao, V. U. M and Venkateswarlu, B. (2014). Vulnerability of Pigeonpea yields to climate change in India – A panel data regression approach. In: International Conference on Climate Change and Sustainable Development Global Perspective. Organized by Institute of Public Enterprise, Osmania University Campus, Hyderabad. February 20-21, 2014

Rao, A. V. M. S., Sravani, P., Rao, V. U. M., Bapuji Rao, B., Vijaya Kumar, P and Pani, P. (2013). Impact of climate change on the productivity of rice at Nellore in South-coastal Andhra Pradesh using DSSAT model. In: Proc. of National Symposium on " Climate change and Indian Agriculture: Slicing Down the Uncertainties" held during 22-23 January 2013 at CRIDA, Hyderabad.

Solaimalai, A., Subbulakshmi, S., Jawahar, D and Rao, V. U. M (2013). Effect of dates of sowing and integrated nutrient management practices on growth, yield attributes and yield of hybrid maize under rainfed vertisol of Tamil Nadu. In: Proc. of National Symposium on "Climate change and Indian Agriculture: Slicing Down the Uncertainties" held at CRIDA, Hyderabad, January 22 & 23, 2013. P: 128-129.

Subbulakshmi, S., Solaimalai, A and Rao, V. U. M. (2013). Response of Bt cotton to different sowing windows and plant spacing under rainfed vertisol conditions. In: Proc. of National Symposium on "Climate change and Indian Agriculture: Slicing Down the Uncertainties" held at CRIDA, Hyderabad, January 22 & 23, 2013. P: 127-128.

Vijaya Kumar, P., Rao, V. U. M., Srikanth, A. and Linitha Nair. (2013). Decision support system for forecasting aphids in mustard crop. In: Proc. of National Symposium on "Climate change and Indian Agriculture: Slicing Down the Uncertainities" held during 22-23 January 2013 at CRIDA, Hyderabad.

Vijaya Kumar, P., Rao, V. U. M., Bhavani, O., Dubey, A. P., Tripathi, P., Sidhu, P. K., Patel, S. R. and Venkateswarlu, B. (2013). Optimizing sowing dates and varieties of wheat through long-term crop and weather analysis. In: Proc. of National Symposium on "Climate change and Indian Agriculture: Slicing Down the Uncertainities" held during 22-23 January 2013 at CRIDA, Hyderabad.

Books / Book chapters / Training program lecture notes

Kaushalya Ramachandran., Venkateshwarlu, B., Ramarao, C. A., Rao, V. U. M., Rao, K. V., Raju, B. M. K., Rao, A. V. M. S., Ramana, D. B. V., Manoranjan, Kumar., Nagasree, K., Ravi Shankar, K., Gayatri, M., Satish, J and Praveen, V. (2013). Assessing Agricultural Vulnerability to Climate Change using NDVI data products. In: "Geospatial Technologies for Natural Resources Management". (Eds. Soam, S. K., Sreekanth, P. D and Rao, N. H.). pp. 345-362.

Nagasree, K., Nirmala, G., Ravi Shankar, K., Manoranjan Kumar., Raju, B. M. K., Ravi Kumar, N., Rao, A. V. M. S and Prasad, M. S. (2013). Training Manual on Model Training Course on "Impact of Climate Change in Rainfed Agriculture and Adaptation Strategies" (Sponsored by D.O.E., Ministry of Agriculture, Government of India, New Delhi) Central Research Institute for Dryland Agriculture, Hyderabad-500 059, India, 208 pp.

Raju, B. M. K., Rama Rao, C. A., Rao, K. V., Venkateswarlu, B., Josily Samuel., Ravi, D., Rao, A. V. M. S., Maruthi Sankar, G. R., Md Osman., Ravi Shankar, K., Nagasree, K., Gopinath, K. A and Swapna, N. (2013). Unreaped yield potential in maize in India. International Year of Statistics 2013. Stat 2013. Socio-Economic Challenges and Sustainable Solutions, December 28-31, 2013. Book of Abstracts. Jointly organized by AIMSCS and University of Hyderabad, 151pp.

Rama Rao, C. A., Raju, B. M. K., Rao, A. V. M. S., Rao, K. V., Rao, V. U. M., Kausalya Ramachandran., Venkateswarlu, B and Sikka, A. K. (2013). Atlas on Vulnerability of Indian Agriculture to Climate Change. National Initiative on Climate Resilient Agriculture (NICRA). Central Research Institute for Dryland Agriculture.

Rao, A. V. M. S. (2013). Database management of Extreme Agrometeorological Events, In: "Agrometeorological aspects of Extreme Weather Events". (Eds. Rao, V. U. M., Rao, A. V. M. S., Vijaya Kumar, P., Bapuji Rao, B and Sastry, P. S. N.). pp. 12-15.

Rao, A. V. M. S., Rao, V. U. M and Bapuji Rao, B. (2013). Agroclimatic analysis for climate variability assessment. In: "Adaptation And Mitigation Strategies For Climate Resilient Agriculture". (Eds. Ravindra Chary, G., Srinivasarao, Ch., Srinivas, K., Maruthi Sankar, G. R., Nagarjuna Kumar, R and Venkateswarlu, B.). 362pp.

Rao. V. U. M. (2013). Climate Change: Risk management through weather insruance. (312-318) In: "Adaptation And Mitigation Stragies For Climate Resilient Agriculture". (Eds. Ravindra Chary, G., Srinivasarao, Ch., Srinivas, K., Maruthi Sankar, G. R., Nagarjuna Kumar, R and Venkateswarlu, B.).

Rao. V. U. M. (2013). Impacts of Climate Change on Agriculture including Animal Agriculture. In: "Fundamentals of Livestock Meteorology - Vol.1". (Eds. Prasada Rao, G. S. L. H. V and Girish Varma, G.).

Rao, V. U. M., Bapuji Rao, B and Venkateswarlu, B. (2013).Agroclimatic Atlas of Andhra Pradesh. Central Research Institute for Dryland Agriculture, Hyderabad-500 059, India, 270pp.

Rao, V. U. M., Rao, A. V. M. S., Vijaya Kumar, P., Bapuji Rao, B and Sastry, P. S. N. (2013). "Agrometeorological Aspects of Extreme Weather Events". Central Research Institute for Dryland Agriculture, Hyderabad-500 059, India, 303pp.

Vijaya Kumar, P. (2013). Monitoring of Near Real Time Agricultural Drought. In: "Adaptation and Mitigation Strategies for Climate Resilient Agriculture". (Eds. Ravindra Chary, G., Srinivasa Rao, Ch., Srinivas, K., Maruthi Shankar, G. R., Nagarjuna Kumar, R and Venkateswarlu, B.).

Vijaya Kumar, P. (2013). Crop-Weather Relationship studies. In: "Agrometeorological aspects of Extreme Weather Events". (Eds. Rao, V. U. M., Rao, A. V. M. S., Vijaya Kumar, P., Bapuji Rao, B and Sastry, P. S. N.). pp. 7-11.

Vijaya Kumar., P., Rao, V. U. M., Tripati, P. K., Venkateswarlu, B. (2014). The Effect of Rice Transplanting Date on Rice-Wheat cropping system Performance in the Middle IGP of India - A simulation study using APSIM. In "SAC Monograph: The SAARC-Australia Project- Developing capacity in cropping systems Modelling for South Asia". (Eds. Gaydon, D. S., Saiyed, I and Roth, C.). pp. 75-85. (SAARC Agriculture Centre, Dhaka, Bangladesh).

Technical & Research bulletins edited / co-edited

Anirudh Prasad, D, Yadav, M. P., Naushad Khan., Singh, C. B and Rao, V. U. M. (2013). Farmers Awareness Programme on Climate Change in Central Uttar Pradesh. AICRPAM Tech. Bul. No. 1/2013. AICRP on Agrometeorology, Agronomy, C.S.A. University of Agriculture & Technology, Kanpur. PP.24.

Gaikwad, U. S., Jadhav, J. D., Kadam, J. R and RAo, V. U. M. (2013). Climate Change Impacts on Dairy Animals. MPKV/RES/PUB.No./79/2013. AICRPAM-NICRA, MPKV, Rahuri.

Jadhav, J. D., Thorve, S. B., Bhore, A. V., Kadam, J. R., Bavadekar, V. R., Upadhe, S. K., Rao, V. U. M and Bhanvase, D. B. (2013). Agro-Met Advisory A success story. MPKV/RES/PUB.NO./78/2013. AICRPAM-NICRA MPKV Rahuri, ZARS, Solapur.

Khushu, M. K., Rajeev Sharma., Sanjay Koushal., Charu Sharma., Rao, V. U. M and Bapuji Rao, B. (2013). Agroclimatic Atlas of Jammu Province (Technical Bulletin-1). Agromet Research Centre, SKUAST- J, Chatah, Jammu.96p.

Khushu, M. K., Sanjay Koushal., Rajeev Sharma., Charu Sharma., Rao, V. U. M and Bapuji Rao, B. (2013). Weather Based Decisions for Cultivation of Kharif Maize crop in Jammu Region (Technical Bulletin-2) 2013. Agromet Research Centre, Sher-e-Kashmir, University of Agricultural Sciences and Technology- Jammu, J&K.

Patel, H. R., Lunagaria, M. M., Vyas Pandey., Sharma, P. K., Bapuji Rao, B and Rao, V. U. M. (2014). El Nino episodes and agricultural productivity in Gujarat. Tech. Bul: 01/2014-15. NICRA-AICRPAM and Centre for Weather Forecasting and Climate Change, AAU, Anand.22pp.

Rajendra Prasad., Ravindra Chary, G., Rao, K. V., Prasad, Y. G., Srinivasa Rao, Ch., Ramana, D. B. V., Sharma, N. K., Rao, V. U. M and Venkateswarlu, B. (2013). District Level Contingency Plans for Weather Aberrations in Himachal Pradesh.CSK HPKV, Palampur, HP & Central Research Institute for Dryland Agriculture. Hyderabad-500 059, India. P.222.

Rao, V. U. M., Bapuji Rao, B., Rajkumar Dhakar., Sarath Chandran, M. A., Vijaya Kumar, P and Rao, A. V. M. S. (2013). Annual Progress Report of All India Coordinated Research Project on Agro meteorology (2012-2013), CRIDA, Hyderabad.

Rao, V. U. M., Bapuji Rao, B., Rajkumar Dhakar., Vijaya Kumar, P and Rao, A. V. M. S. (2013). National Initiative on Climate Resilient Agriculture-AICRPAM Component, Annual Report 2012-2013, CRIDA, Hyderabad.

Solaimalai, A., Subbulakshmi, S., Jawahar, D and Rao, V. U. M. (2013). Farmer's awareness manual on Climate Change Impact on Agricultural and its Management. ARS, Kovilpatti p.25. (in Tamil).

Sthool, V.A., S.K. Upadhaye., J.D. Jadhav., V.U.M.Rao., R.V. Sanglijkar and J.R. Kadam (2013). Farm Pond – A Boost for Sustainability in Dryland under Climate Change Situation.MPKV/Res.Pub. No. 80/2013.

Venkatesh, H., Rajput, R. B., Nashi, S. B., Hiremath, J. R., Kulkarni, S. N., Bapuji Rao, B and Rao, V. U. M. (2013). Farmer, Weather & Climate: Perception of Farmers on Climate and Agriculture. National Initiative on Climate Resilient Agriculture AICRP on Agrometeorology, Technical Bulletin-3, Regional Agricultural Research Station Bijapur, University of agricultural Sciences, Dharwad, Karnataka.

Venkateswarlu, B., Maheswari, M., Srinivasa Rao, M., Rao, V. U. M., Srinivasa Rao, Ch., Reddy, K. S., Ramana, D. B. V., Rama Rao, C. A., Vijay Kumar, P., Dixit, S and Sikka, A. K. (2013). National Initiative on Climate Resilient Agriculture (NICRA), Research Highlights (2012-13).Central Research Institute for Dryland Agriculture, Hyderabad.111 p.

Popular articles authored / co-authored in press and Magazines

Bapuji Rao, B., Rao, V. U. M and Rao, A. V. M. S. (2014). El-Nino-Andhra Telangana rashtrala vyvasayarangaani prabhavitham chaiyanundha? Raythunestham (Agriculture family Monthly magazine May 2014. 41-44.

AICRPAM Centres Publications:

Akola

Indian Journals

Gayatri Devi, K., Karunakar, A. P and Gopinath, K. A. (2013). Integrated weed management in rainfed soybean. Indian J. Dryland Agric. Res. Dev., 27(2): 2012 (Published in April 2013).

Maruthi Sankar, G. R., Sharma, K. L., Gabhane, V. V., Nagdeve, M. B., Osman, M., Pushpanjali., Gopinath, K. A., Reshma, Shinde., Ganvir, M. M., Karunakar, A. P., Anitha., Chorey., Mishra, P. K., Venkateswarlu, B., Singh, A. K., Suma Chandrika, M and Sammi Reddy, K. (2013). Effects of Long-Term Fertilizer Application and Rainfall Distribution on Cotton Productivity, Profitability, and Soil Fertility in a Semi-arid Vertisol. Commun. Soil Sci. Plant Anal., 45:362–380.

Papers presented in National and International Symposia / Seminars

Ganvir, M. M., Nagdeve, M. B., Gabhane, V. V., Karunakar, A. P and Usha Satpute. (2014). Influence of Different Row Proportion of Pigeonpea on Productivity and Economics in Soybean+ Pigeonpea Intercropping System. In: International Soybean Research Conference (SOYCON-2014) 22-24 February, 2014 at Indore.

Anand

International Journals

Yadav, S. B., Patel, H. R., Parmar, P., Karande, B. I and Vyas Pandey. (2013). Effect of date of sowing, varieties and irrigation regimes on pod yield of Kharif groundnut in middle Gujarat Agro-climatic condition. International Journal of Agricultural Sciences and Technology. 2(1): 13-18

Indian Journals

Guled, P. M., Shekh, A. M., Patel, H. R and Vyas Pandey. (2013). Effect of soil moisture, evapotranspiration, stress degree days on pod yield of groundnut. J. Agrometeorol., 15 (Special Issue-II): 135-137.

Mishra S. K., Shekh, A. M., Yadav, S. B., Kumar, A., Patel, G. G., Vyas Pandey and Patel, H. R. (2013). Simulation of growth and yield of four wheat cultivars using WOFOST model under middle Gujarat region. J. Agrometeorol., 15(Special Issue-I): 43-50.

Parmar, P. K., Patel, H. R., Yadav, S. B and Vyas Pandey. (2013). Calibration and validation of Kharif groundnut using DSSAT model for north Saurashtra Agroclimatic zone of Gujarat. J. Agrometeorol., 15(Special Issue-I): 62-65.

Patel, H. R., Lunagaria, M. M., Parmar, P. K., Karande, B. I., Vyas Pandey., Yadav, S. B., Shah, A. V., Rao, V. U. M and Nareshkumar, S. (2013). Impact of projected climate change on groundnut in Gujarat. J. Agrometeorol., 15(Special Issue-I): 41-44.

Papers presented in National and International Symposia / Seminars

Patel, H. R. (2013.) Climate resilient agriculture using weather based Agro Advisory services. In: National conference on "Capacity building of farmers on tools, techniques and applications of weather forecasting: An integrated adaptation perspective" held at AAU Anand during 15-17 March 2013 organized by NCCSD and AAU.

Patel, H. R., Yadav, S. B., Lunagaria, M. M., Parmar, P. K., Chaudhari, N. J., Karande, B. I and Vyas Pandey. (2013). Impacts of climate change on growth and yield of rice in middle Gujarat agro- climatic region. In: Proceeding of National Seminar on "Climate Change Impact on Water Resource System" pp13-17. (At Parul institute Vadodara held on 23-24 October).

Yadav, S. B., Patel, H. R., Lunagaria, M. M., Chaudhari, N. J., Karande, B. I and Vyas Pandey. (2013). Impact assessment of projected climate change on pearlmillet in Gujarat. In: Proceeding of National Seminar on "Climate Change Impact on Water Resource System" at Parul institute Vadodara held on October at Parul institute Vadodara held on 23-24 October. pp. 33-38.

Anantapur

Popular articles authored / co-authored in press and Magazines

Dhanunjay, V., Malleswari, S. N., Sahadeva Reddy, B., Vijaya Sai Reddy, M and Pratap Kumar Reddy, A. (2013). Importance of quality seed in reeping higher yields. Annadatha, June, 2013.

Dhanunjay, V., Malleswari, S. N., Sahadeva Reddy, B., Vijaya Sai Reddy, M and Pratap Kumar Reddy, A. (2013). Seed production by Farmers. Annadatha, June, 2013.

Technical & Research bulletins edited / co-edited

Sahadeva Reddy, B., Malleswari Sadhineni, S. N., Radhika, P., Ashoka Reddy, Y., Pratap Kumar Reddy, A. (2013). Samgra Vyavasayam – Rythu Jeevanaadhara Susthiratha – Suchanalu. (Technical Bulletin – Telugu).

Radio Talks:

Malleswari, S. N., Gave two radio talks on “Bt cotton production technology” and “Use of herbicides for weed management in various crops”, which were broadcasted on 31.07.2013 and 02.05.2014 in AIR, Anantapur.

Bengaluru

Technical & Research bulletins edited / co-edited

Rajegowda, M. B., Janardhana Gowda, N. A., Raghavendra, S., Thimme Gowda, P. R and Sridhar, D. (2013). “Economic Impact of National Initiative on Climate Resilient Agriculture” (Bangalore centre) released during ARM held at UAS, Dharwad during 16.9.13 to 17.9.13.

Rajegowda, M. B., Janardhana Gowda, N. A., Soumya, D. V and Padmashri, H. S. (2013). Forecasting agricultural output using space, agrometeorology and land based observations (FASAL).

Rajegowda, M. B., Janardhana Gowda, N. A., Padmashri, H. S., Soumya, D. V., Nagesha, L and Sridhar. (2013). Weather triggers for the rainfed crops grown in southern districts of Karnataka state.

Rajegowda, M. B., Janardhana, Gowda, N. A., Padmashri, H. S and Ravindra Babu, B. T. (2013). “Climatic Characterization of Gandhi Krishi Vignana Kendra”.

Popular articles authored / co-authored in press and Magazines

Rajegowda, M. B., Janardhana Gowda, N. A., Sridhar, D and Nagesha, L. (2013). Havamana Badalavaneyindagi Sasya Rogagalu hagu Keetagala melaguva Parinaamagalu. Published in Krushi Kayaka (April - June 2013) 3(4):28-29.

Rajegowda. M.B., Janardhana Gowda, N.A., Thimme Gowda. P. R and Raghavendra. N. (2013). Krushi Havamana Munsoochana Varadhi Kurithu Raithara Abhipraya. Published in Krushi Kayaka (April - June 2013) 3(2):13.

Rajegowda, M. B., Janardhana Gowda, N. A., Soumya, D. V and Nagesha, L. (2013). Krishi havaamana salaha varadhi.

Rajegowda, M. B., Janardhana Gowda, N. A., Padmashri, H. S and Pradeep Gopakkali. (2013). Havaamana badalavane mathu krishi.

Rajegowda, M. B., Padmashri, H. S., Soumya, D. V and Janardhana Gowda, N. A. (2014). Havamana Adharitha Bele Vime Yojane. Published in Krushi Kayaka (January to March- 2014) 4(1):18-20.

T.V. Programmes Attended: 6

Radio Talks given through AIR: 8

Bijapur

Indian Journals

Thimme Gowda, P., Halikatti, S. I., Venkatesh, H., Hiremath, S. M and Aravindkumar, B. N. (2013). Phenology, thermal time and phasic development of pigeonpea (Cajanus cajan L. Millisp.) grown under intercropping system. J. Agrometeorol., 15(Special issue-II): 129-134.

Venkatesh, H., Nashi, S. B., Hiremath, J. R., Nargund, V. B and Kulkarni, S. N. (2013). Adoption of weather forecasts – A precursor towards adaptation to climate change. J. Agrometeorol., 15(Special Issue-II): 01-05.

Technical & Research bulletins edited / co-edited

Venkatesh, H., Rajani B. R., Hiremath, J. R., Shashikumar, S., Chougla, D. C and Malwadi, M. N and Sharmas, S. H. (2013). Climate Resilience through Micro-level Agromet Advisories. Technical Bulletin -3, 2013. AICRP-NICRA, Bijapur Centre. (Kannada).

Venkatesh, H., Rajani B. R., Nashi, S. B., Hiremath, J. R., Kulkarni, S. N., Bapuji Rao, B and Rao, V. U. M. (2013). Farmer, Weather and Climate: Perception of Farmers on Climate and Agriculture. Technical Bulletin -2, 2013. AICRP-NICRA, Bijapur Centre.

Popular articles authored / co-authored in press and Magazines

Venkatesh, H., Malawadi, M. N., Rajani B. R., Hiremath, J. R., Shashikumar, S and Naveen, N. E. (2013). Crop selections for Belgaum district based on Nakshatra period wise rainfall distribution. (In Kannada).

Dapoli

Popular Articles /Leaflets

Thorat, S. T. (2013). Rice Nursery Management, Krishi Panan Mitra Magzine, July, 13-14.

Chatha/Jammu

International Journals

Vishal Gupta., Naveed Shamas., Razdan, V. K., Sharma, B. C., Rishu Sharma., Kavaljeet Kaur., Ichpal Singh., Dolly John and Atul Kumar. (2013). Foliar application of fungicides for the management of brown spot disease in rice (Oryza sativa L.) caused by Bipolaris oryzae. Afr. J. Agric. Res., 8(25): 3303-3309.

Vishal Gupta., Ahanger, R. A., Razdan, V. K., Sharma, B. C., Ichpal Singh., Kavaljeet Kaur and Pandey, M. K. (2013). Prevalence and distribution in different agro-ecologies and identification of resistance source for wheat stripe rust. Afr. J. Agric. Res., 8(25): 3268-3275.

Indian Journals

Brij Nandan., Sharma, B. C and Anil Kumar. (2013). Effects of Mustard-Maize intercropping system on productivity of Maize in moisture deficit sub tropical areas of Jammu and Kashmir. Scholarly Journal of Agricultural Sciences. 3(2): 66-72.

Brij Nandan., Sharma, B. C and Anil Kumar. (2013). Mitigating Food Security options through climate resilient mustard-maize based intercropping sequences for North-western- Himalayas. Journal of Food Security. 1: 58-64.

Gaganpreet Kour., Wali, V. K., Khushu, M. K., Parshant Bakshi., Akash Sharma and Charu Sharma. (2013). Studies on the irrigation scheduling in low chilling cultivars of peach under subtropical conditions. J. Agrometeorol., 15(Special Issue-II): 212-216.

Gupta, V., Razdan, V. K., John, D., Sharma, B. C. (2013). First report of Leaf Blight of Cyperus iria caused by Fusarium equiseti in India. Plant Dis., 97(6): 838.

Khush, M. K., Charu Sharma., Sanjay Koushal., Rajeev Sharma., Bapuji Rao, B and Rao, V. U. M. (2013). Simulation of phenology, growth and yield of maize in a humid sub-tropical region of India using CERES-Maize Model. J. Agrometeorol., 15(Special Issue-II): 222-226.

Kour, P., Kumar, A., Sharma, B. C., Kour, R., Kumar, J., Sharma, N. (2013). Effect of weed management on crop productivity of winter maize (Zea mays) + potato (Solanum tuberosum) intercropping system in Shiwalik foothills of Jammu and Kashmir. 59(1): 65-69.

Ranjeet Kour., Sharma, B. C., Anil Kumar and Kour, P. (2013). Nutrient uptake by chickpea + mustard intercropping system as influenced by weed management. Indian Journal of Weed Science. 45(3): 183–188.

Ranjeet Kour., Sharma, B. C., Anil Kumar., Brij Nandan and Kour, P. (2013). Effect of weed management treatments on chickpea (Cicer arietinum) + Indian mustard (Brassica juncea) intercropping system under irrigated subtropical conditions of Jammu region. Indian J. Agron., 59 (2): 39-43.

Vikas Gupta., Mahender Singh., Anil Kumar., Sharma, B. C and Deepak Kher. (2013). Influence of weed managemebnt practices on weed dynamics and yield of urd bean (vigina mungo) under rainfed conditions of Jammu. Indian J. Agron., 58(2): 220-225.

Faizabad

International Journals

Mishra, A. N., Kumar, A., Singh, A. K and Tripathi, P. (2014). Seasonal and annual variability of major climatic parameters in Eastern Uttar Pradesh. Int. J. Agril. Sci. 5(1):99-102.

Singh, A. K., Singh, R. R., Singh, A. K and Singh, P. K. (2014). Response of date of sowing and irrigation scheduling on growth and yield of mustard. International Journal of Farm Science Solan. 4(2):80-85.

Singh, P. K and Singh, A. K (2014). Effect of sowing date and irrigation schedules on yield and quality of Indian mustard (Brassica juncea L). J. Soil Water Conserv., (Revised).

Indian Journals

Deepak Kumar., Singh, R. A and Singh, A. K (2013). Response of date of sowing and Nitrogen schedules on growth and yield of late sown wheat. Paper accepted in Narendra Deva Journal of Agric. Research, NDUAT Kumarganj Faizabad.

Kumar A., Tripathi, P and Singh, A. K. (2013). Rainfall Variability Analysis of Uttar Pradesh for crop planning and Management. Mausam. (Revised)

Prakriti., Mishra, B.P and Tripathi, P. (2013). Study of eco-environment of paddy-fish farming under lowland rice ecosystem. Fishing Chim. (Communicated).

Singh, A.K., Mishra, S.R and Tripathi, P (2014). Growth and Yield of Potato as Influenced by Bio-Fertilizer & Fertility levels. Jr. of Research, NDUA&T., (submitted)

Singh, A.K., Mishra, S.R and Tripathi, P (2014). Yield and quality of Potato as Influenced by Bio-Fertilizer & Fertility levels. Jr. of Research , NDUA&T., (submitted)

Tripathi, P. (2014). CERES-Rice model in the prediction of growth and yield of ruling rice cultivars under EPZ climatic condition of Uttar Pradesh. Indian J. Agr. Res., (Communicated)

Papers presented in National and International Symposia / Seminars

Deepak Kumar., Singh, R. A and Singh, A. K. (2013). Effect of sowing time and Nitrogen schedules on growth and yield of late sown wheat. In: Ist U.P. Agri Science congress held during 17-19 August 2013 at NDUAT Faizabad U.P.

Krishna Deo., Tripathi, P and Mishra S. R. (2013). "Variability analysis of rainfall in different regions of U. P." In: Ist U.P. Agric. Science congress held at NDUAT Kumarganj on dated 17-19 August, 2013.

Singh, G., Singh, A. K and Tripathi, P. (2013). Study of perception of Climate Awareness constraints and impact of weather forecast in Bahraich district. In: Ist U.P. Agriculture Science congress held at NDUAT Kumarganj on dated 17-19 August, 2013.

Singh, S. P., Singh, A. K and Mishra, S. R. (2014). The impact of weather variability on rice production. In: Ist National Seminar on Science and Innovation, held at B.R.D.P.G. College Deoria on 14 Feb, 2014.

Tripathi, P. (2014). Impact Analysis of Climate Change in North-West India for Crop Planning and Management-A Case Study in Reference to the Rainfall. In: 31st Conference on Agricultural and Forest Meteorology, during 12-15 May, 2014 in Portland, Oregon (USA).

Books / Book chapters / Training program lecture notes

Kumar A., Tripathi, P and Singh, A. K. (2013). "Drought and Rice in Tropics". 1st Eds. (Lambert Academic Publishing Company, Germany).

Tripathi, P. (2014). Crop Modeling for Agriculture Production and Management. In: "Climate Change Effect on Crop Productivity". (Accepted).

Tripathi, P. (2014). "An approach to integrated Paddy-Fish farming". Ist Eds. (Scholar press Germany). (Accepted).

Vijaya Kumar., P., Rao, V. U. M., Tripati, P. K., Venkateswarlu, B. (2014). The Effect of Rice Transplanting Date on Rice-Wheat cropping system Performance in the Middle IGP of India - A simulation study using APSIM. In "SAC Monograph: The SAARC-Australia Project- Developing capacity in cropping systems Modelling for South Asia". (Eds. Gaydon, D. S., Saiyed, I and Roth, C.). pp. 75-85. (SAARC Agriculture Centre, Dhaka, Bangladesh).

Popular articles authored / co-authored in press and Magazines

Tripathi, P., Mishra, S. R., Singh, A. K and Kumar, A. (2013). Monsoon ke Vilamb ki awastha me dhan ke adhik utpadan ke chamtkari paddhati (SRI). Article published in Srishti Agro Newspaper, Mumbai.

Tripathi, P., Kumar, A and Singh, A. K. (2013). Gahui ki Mausam Adharit Vaigyanic Kheti. Article published in Srishti Agro Newspaper, Mumbai.

Tripathi, P., Mishra, S. R., Singh, A. K and Kumar, A. (2013). Monsoon ki chal avm kheti ka hal. Article published in Srishti Agro Newspaper, Mumbai.

Tripathi, P. (2014). Barish se genhu ke fasal ko fayda. Published in Gaon Connection. Hindi news paper 2(12) Lucknow 23 Feb.2014 page12.

Tripathi, P. (2014). Thoda pahle mausam ka mijaj bhanp le to kam ho nuksan. Published in Gaon Connection. Hindi news paper. 16-22 March 2014.

Radio/T.V. talks

Dr. A. K.Singh delivered 2 Radio talks at Akashvani Faizabad.

Dr. P. Tripathi delivered 3 Radio talks at Akashvani Faizabad and Gorakhpur and three T.V. talks at Lucknow and Gorakhpur Doordarsan during reporting year.

Hisar

Indian Journals

Jugal K Mani., Raj Singh., Diwan Singh and Rao, V.U. M. Rao. (2013). Variations in radiation use efficiency of wheat (Triticum aestivum L.) as influenced by thermal stress management strategies under late sown conditions. J. Agrometeorol., 15: 138-141.

Jugal K. Mani., Raj Singh., Diwan Singh and Pannu, R. K. (2013). Growth indices of wheat (Triticum aestivum L.) as influenced by thermal stress management strategies under late sown conditions. Res. Crop., 14: 42-47.

Parvinder Kumar., Surender Singh and Diwan Singh. (2013). Regional climate variability and analysis and impact assessment on wheat productivity: A case study in Haryana. J. Agrometeorol., 15(Special Issue-II): 235-237.

Raj Singh., Karwasra, S. S., Barun Biswas and Diwan Singh. (2013). Development of predictive model for karnal bunt of wheat. J. Agrometeorol., 15(Special Issue-I): 112-114.

Suchandan Bemal., Diwan Singh and Surender Singh. (2013). Impact analysis of climate variability on rice productivity in eastern agroclimatic zone of Haryana by using DSSAT crop model. J. Agrometeorol., 15(Special Issue-II): 80-85.

Radio / TV Talks:

Radio talk on 'Weather impact on agriculture operations during in rabi crops' was delivered on AIR Hisar.

Periodical discussion on 'Role of weather in agriculture' and 'Weather forecast for farmers' were telecasted on local channels including DD Hisar, Total TV, PTC, Haryana News, and Cable Network etc.

Kanpur

Indian Journals

Awasthi, U. D., Uttam, S. K., Tripathi, A. K., Yadav, P. N., Dubey, A. P., Gupta, G. R and Verma D. K. (2013). Effect of planting pattern on productivity and water use efficiency of seasame (Sesamum indicum) intercropping with pulse under rainfed condition. Current Advances in Agricultural Sciences. 5(1): 266-268.

Technical Bulletins:

Dubey, A. P., Yadav, M. P., Khan, N., Singh, C. B and Rao, V. U. M. (2013). Farmers Awareness Program on Climate Change in Central Plain Zone of Uttar Pradesh. C. S. A. University of Agriculture & Technology, Kanpur. Page-24.

Dubey, A. P., Yadav, M. P., Khan, N and Rao, V. U. M. (2013). Weather based decision for growing rice in Central Uttar Pradesh. C. S. A. University of Agriculture & Technology, Kanpur. Page-76.

Dubey, A. P and Yadav, M. P. (2013). Practical manual in Agrometeorology. C. S. A. University of Agriculture & Technology, Kanpur. Page-46.

Popular articles authored / co-authored in press and Magazines

डा. अनिरुद्ध दुबे खाद्यान्न भण्डारण,कृषि चिंतन, प्रसार शिक्षा एवं प्रशिक्षण ब्यूरों, कृषि विभाग 9, विश्वविद्यालय मार्ग, लखनऊ।

डा. अनिरुद्ध दुबे मौसम के अनुसार माह जनवरी मे की जाने वाली कृषि सस्य क्रियाए ं(जनवरी 2013) । कृषि चिंतन, प्रसार शिक्षा एवं प्रशिक्षण ब्यूरों, कृषि विभाग 9, विश्वविद्यालय मार्ग, लखनऊ। प्र. सं.– 2–5।

डा. अनिरुद्ध दुबे मौसम के अनुसार माह जनवरी मे की जाने वाली कृषि सस्य क्रियाए ं(फरवरी 2013)। कृषि चिंतन, प्रसार शिक्षा एवं प्रशिक्षण ब्यूरों, कृषि विभाग 9, विश्वविद्यालय मार्ग, लखनऊ। प्र. सं.– 2–5।

डा. अनिरुद्ध दुबे मौसम के अनुसार माह मार्च मे की जाने वाली कृषि सस्य क्रियाएं(मार्च 2013)। कृषि चिंतन, प्रसार शिक्षा एवं प्रशिक्षण ब्यूरों, कृषि विभाग 9, विश्वविद्यालय मार्ग, लखनऊ। प्र. सं.– 2–5।

डा. अनिरूद्ध दुबे, नौशाद खान, डी.डी. यादव एवं डा. एम.पी. यादव 'परिवर्तित वातावरण का फसलों पर प्रभाव' कृषक भारती, (खरीफ विशेषांक 2012), विश्वविद्यालय प्रेस, च. शे. आ. कृषि एवं प्रौ. वि. वि., कानपुर।

Radio / TV Talks:

T.V. talks on the topic of weather based management on kharif, rabi and zaid crops were delivered by Dr. A. P. Dubey in Local and National news channels by weekly or weekly.

Kovilpatti

Indian Journals

Jayakumar, M., Rajavel, M and Solaimalai, A. (2013). Climate variability and yield of coffee in Kerala. AARJMD, 1(15): 343 - 365.

Jayakumar, M., Rajavel, M and Solaimalai, A. (2013). Influence of weather on mealy bug of robusta coffee in Wayanad. AARJMD. 1(15): 366 - 379.

Technical & Research bulletins edited / co-edited

Solaimalai, A., Subbulakshmi, S., Jawahar, D and Rao, V. U. M. (2013). Long term rainfall analysis for Thoothukudi District of Tamil Nadu. Agricultural Research Station, Kovilpatti, Tamil Nadu. 156 p.

Radio /Doordarsan Talks

Dr. A. Solaimalai delivered Doordharsan talk on 'Sowing windows for dryland crops in Southern agroclimatic zone' on 06.03.2014.

Dr. S. Subbulakshmi delivered Doordharsan talk on 'Crop production practices for climate change' on 06.03.2014.

Dr. S. Subbulakshmi gave Doordharsan talk on 'Integrated weed management in rainfed agriculture' on 06.03.2014.

Ludhiana

International Journals

Ashu Bala and Prabhjyot Kaur. (2013). Formulation of weather based "Weekly Thumb Rule Models" for prediction of potential productivity of wheat in Punjab. International J. of Agriculture and Plant Science. 1(1): 17-32.

Chauhan B. S., Prabhjyot Kaur., Mahajan, G., Randhawa, R. K., Singh, H and Kang, M. S. (2014). Global Warming and Its Possible Impact on Agriculture in India. Adv. Agron., 123: 65 -121.

Gill, K. K., Kukal, S. S., Sandhu, S. S and Brar, H. S. (2013). Spatial and temporal variation of extreme rainfall events in central Punjab. International Journal of Applied Engineering Research. 8(15): 1757-1764.

Sandhu S. S., Prabhjyot Kaur and Gill, K. K. (2013). Weather based agro indices and grain yield of rice cultivars transplanted on different dates in Punjab. International J. Agri. Food Sci Technology. 4(10): 1019-1026.

Indian Journals

Bal, S. K., Choudhury, B. U., Sood, A., Saha, S., Mukherjee, J., Singh, H and Prabhjyot Kaur. (2013). Relationship between leaf area index of wheat crop and different spectral indices in Punjab. J. Agrometeorol., 15(Special Issue-II): 98-102.

Kamal Vatta., Prabhjyot Kaur., Harpreet Singh and Grover, T. (2013). Trends in vulnerability of Punjab agriculture: A district-wise multi-dimensional index approach. J of Agricultural Development & Policy. 23(1): 83-95.

Kingra. P. K and Prabhjyot Kaur. (2013). Agroclimatic study for prediction of growth and yield of Brassica sp. in central Punjab. J. Res. Punjab Agric. Univ., 13(2): 2-9.

Kingra. P. K and Prabhjyot Kaur. (2013). Phenology and growth dynamics of groundnut (Arachis hypogaea L.) cultivars under different dates of sowing. J. Res. Punjab Agric. Univ., 50(1&2): 24 – 31.

Prabhjyot Kaur and Ashu Bala. (2013). Development of crop-weather-pest calendars for wheat crop in Punjab. J. Res. Punjab Agric. Univ., 50(3&4): 99-109.

Prabhjyot Kaur and Ashu Bala. (2014). Development of crop-weather-pest calendars for rice crop in Punjab. J Res Punjab Agric Univ. 51(1): 18-27.

Prabhjyot Kaur., Harpreet Singh., Kingra, P. K and Mukherjee, J. (2013). OILCROP-SUN model as a grower's tool for sunflower cultivation in irrigated plains of Punjab, India. Journal of Agricultural Physics. 13(2): 166-174.

Sandhu, S. S., Prabhjyot Kaur., Gill, K. K and Ashu Bala. (2013). Effect of inter and intra-seasonal variability in meteorological parameters on rice productivity in central Punjab. J. Agrometeorol., 15(Special Issue-II): 147-151.

Popular articles:

Kukal S. S and Prabhjyot-Kaur. (2013). Punjab must study climate change effect. The Tribune August 22, 2013.

Kulwinder, K., Gill, K. K., Kukal, S. S and Prabhjyot Kaur. (2013). Monsoon rainfall variations in Punjab. Progressive Farming July 2013 : 26-27.

Mohanpur

International Journals

Barma, P., Jha, S and Banerjee, S. (2013). Prediction of population development of melon fruit-fly (Bactrocera cucurbitae Coq.) on pointed gourd (Trichosanthes dioica Roxb.). Afr. J. Agric. Res., 8(38): 4740-4747.

Indian Journals

Banerjee, S., Chatterjee, S., Mukherjee, A., Samanta, S and Bose, M. (2013). Variation of crop evapotranspiration from the potato field at two selected locations of West Bengal, India. J. Agrometeorol., 15(Special Issue-II): 64-66.

Bera, N., Banerjee, S., Sharma, K., Nanda, M. K., Bhattacharya, B and Khan, D. K. (2013). Determining pootential yield and effect of change of transplanting date on yield of Kharif rice through croop growth simulation model. Jour. Agric. Physics., 13: 80-85.

Mukherjee, A., Banerjee, S., Samanta, S. Chakraborty, A. J and Deka, N. (2013). Variation of absorbed PAR and yield of different Kharif rice cultivars influenced by date of transplanting. J. Agrometeorol., 15:126-128.

Papers presented in National and International Symposia / Seminars

Banerjee, H., Banerjee, S and Puste, A. M. (2013). Contingency crop planning for varied weather conditions to improve livelihood of dry-land areas in India. In: Proceedings of the International Conference on Climate Change Impact and Adaptation, 14-16 Nov., 2013, DUET, Gazipur, Bangladesh.

Palampur

Indian Journals

Books / Book chapters / Training program lecture notes

Prasad, R., Sehgal, S., Kumar, S and Sharma, A (2012). Early Warning Systems. In: "Protecting livelihoods by designed resilience to stresses in western Himalayas". (Eds. Ahuja, P. S and Chopra, V. L.). (In press).

Popular articles authored / co-authored in press and Magazines

Prasad, R., Sehgal, S and Sharma, A. (2013). Varsh 2013 mein monsooni varsha ka purvanumaan evam kisano koslaah. Parvitye Khetibari, Quarterly Hindi Magazine, CSK HPKV, Palampur (issue July-September). pp. 20.

Prasad, R and Shekhar, J. (2013). Jila stariye vaikalpik Krishi yojnayen- Jalvayua nishchitta ke prabhaavko kam karnekaek nishchitupaye. Parvitye Khetibari, Quarterly Hindi Magazine, CSK HPKV, Palampur (issue July-September). pp. 25-30.

Prasad, R., Sehgal, S and Sharma, A. (2013). Mausamanuroop tikau kheti par jagrukta abhiyan. Parvitye Khetibari, Quarterly Hindi Magazine, CSK HPKV, Palampur (issue July-September). pp. 5-6

Prasad, R., Sharma, A and Sehgal, S. (2013). Jalvayu parivartan, mukhya kaaran v krishi par prabhav. Parvitye Khetibari, Quarterly Hindi Magazine, CSK HPKV, Palampur (issue July-September). pp. 8-9

Prasad, R and Badiyala, D. (2013). Jalvayu parivartan se nipatne ke liye Akhil Bharatiye Samanvey Anusandhan Paryojna. Parvitye Khetibari, Quarterly Hindi Magazine, CSK HPKV, Palampur (issue July-September). pp. 3-4

Parbhani

International Journals

Zanwar, P. R., Deosarkar, D. B., Bhosle, B. B., Yadav, G. A., Shelke, L. T and Jadhav, M. G. (2014). Relationship between weather parameters with population of major sucking pests in transgenic cotton. J. Cotton Res. Dev. 28(1): 112 – 115.

Technical Bulletins:

Kamble A. M., Bhuibhar., Jadhav, M. G., Pendke, M. S and Kadale, A. S. (2013). Rainfall – Dry spell analysis of Marathwada region for crop planning (2013) published in Joint AGRESCO held at VNMKV, Parbhani.

Ranchi

Research publications:

Kumari, J, Wadood, A., Kumari, P and Ramesh, K. (2012). Impact of temperature variation on phenology and performance of wheat cultivers under the climatic conditions of Ranchi. Journal of Research (BAU). 24(1): 23-29.

Kumari, P., Ojha, R., Wadood, A and Ramesh, K. (2014). Rainfall and drought characterization for crop planning in Palamu region of Jharkhand. Mausam. 65(2):67-72.

Ranichauri

International Journals

Thakur, Deepshikha., Kaushaland, R and Upadhyay, R. G. (2014). Isolation and characterization of efficient plant growth promoting cellulotytic and phosphate solubilizing micro organism for the preparation of bioactive phosphocompost from the agrowaste. International Journal of Research in Biosciences, Agriculture and Technology., 2(2):557-562.

Papers presented in National and International Symposia / Seminars

Thakur, D., Mohinder, K., Upadhyay, R. G and Shyam, V. (2013). Production of acid phosphatase by fluorescent Pseudomonas isolated from the normal and replant sites of apple and pear. In: Proceeding of International Conference on Health, Environment and Industrial Biotechnology held at Motilal Nehru Engineering College, Allahabad U. P. on dated 21st-23rd November. pp. 130-133.

Samastipur

Indian Journals

Books / Book chapters / Training program lecture notes

One booklet “Drought: Agricultural Aspects, Vulnerability Assessment and Strategic Appraisal in Bihar”

Technical & Research bulletins edited / co-edited

Pandey, I. B., Alam, M. I and Kumar, M. (2014). Krishi par jalvayu parivartan ka dusprabhav tatha unke bachav ke upaye. Bulletin Vol. 2.

Popular articles authored / co-authored in press and Magazines

Alam, M. I., Pandey, I. B., Kumar, M and Bobde, P. R. (2014). Mausam ke badlav ka Krishi par dusprabhav evum unka nirakaran. Adhunik Kisan. (Jan-March-2014):11-12.

Solapur

International Journals

Ghule, P. L., Palve, D. K., Jadhav, J. D and Dahiphale, V. V. (2013). Plant geometry and nutrient levels effect on productivity of Bt cotton. International Journal of Agricultural Science. 09 (02): 165-172.

Indian Journals

Akashe, V. B., Gud, M. A., Shinde, S. K., Jadhav, J. D., Bavadekar, V. R and Kadam, J. R. (2013). Weather based forewarning models for safflower aphid in the scarcity zone of Maharashtra. *J. Agrometeorol*., **15**(Special Issue-I): 1-5.

Chavan, S. R., Satpute, N. R., Jadhav, J. D and Waghmare, J. M. (2013). Mutation breeding in African marigold. *Contemporary Research in India*. **03**(02): 40-42.

Murumkar, D. R., Indi, D. V., Gud, M. A., Shinde, S. K., Jadhav, J. D., Bavadekar, V. R and Kadam, J. R. (2013). Weather based forewarning model for safflower alternaria in the scarcity zone of Maharashtra. *J. Agrometeorol*., **15**(Special Issue-I): 66-70.

Satpute, N. R., Jadhav, J. D., Waghmare, J. M and Jadhav, M .B. (2013). Pottassium sources-levels and its effects on growth and yield parameters of lilum. *Contemporary research in India*. **03**(02): 19-24.

Satpute, N. R., Waghmare, J. M., Jadhav, J. D and Jadhav, M. B. (2013). Potassium sources levels and its effects on growth and yield parameters of lilum. An Asian journal of soil science **08**(02): 432-437.

Satpute, N. R., Waghmare, J. M., Jadhav, J. D and Jadhav, M. B. (2013). Effect of different sources and levels of potassium on yield quality and nutrient uptake by Lilum grown under polyhouse condition. *Contemporary Research in India*. **03**(02): 1-7.

Shinde, S. K., Jadhav, J. D., Khadtare, S. V and Kadam, J. R. (2013). Phenophase prediction in Safflower. *J. Agrometeorol*., **15**(Special Issue-I): 11-12.

Upadhye, S. K., Jadhav, J. D., Pawar, P. B., Bavadekar, V. R and Kadam, J. R. (2013). Use of probability models for prediction of rainfall at Solapur, Maharashtra. *J. Agrometeorol*., **15**(Speciall Issue-I): 04-06.

Books / Book chapters / Training program lecture notes

Akashe V. B and Jadhav J. D. (2013). "Badaltya Hawamanat Jaiwik Ghatkanche Mahatwa" (Marathi).

Technical & Research bulletins edited / co-edited

Gaikwad U. S., Jadhav, J. D., Kadam, J. R and Rao, V. U. M. (2013). "Climate change impacts on Dairy animals". MPKV /Res.Pub.No.79 / 2013.

Jadhav, J. D., Thorve, S. B., Bhore, A. V., Bavadekar, V. R., Upadhye, S. K., Rao, V. U. M and Kadam, J. R. (2013). "Agro-Met Advisory-A success story. MPKV /Res.Pub.No.78 / 2013

Sthool, V. A., Upadhye S. K., Jadhav, J. D., Sanglikar, R. V., Rao, V. U. M and Kadam, J. R. (2013). "Farm pond–A boost for sustainability in dryland under climate change situation". MPKV /Res.Pub.No/.80 / 2013.

Radio / TV Talks:

Awards from recognized institute/ICAR institute Jadhav, J. D. awarded Dr. Radhakrishnan Gold Medal Award In the 14th National seminar on contribution to education and National development organized on 19 October 2013 at Chennai.

Every week Agro Advisory Broad casted + 02 own programme Regular weather forecasting on early morning and on every Wednesday at 07:30 pm in Gaonkari mandal on AIR Solapur regarding Agro-Advisory Service.

Award:

Jadhav, J. D awarded Rashtriya Gaurav Award by India International Friendship Society, New Delhi (2014).

Thrissur

Papers presented in National and International Symposia / Seminars

Karthika, V. P., Prasada Rao, G. S. H. L. V., Ajith Kumar, B., Laly John, C and Pradeepkumar, T. (2012). Influence of weather variables on the curd yield of cauliflower (Brassica oleracea var. botrytis) in the central region of Kerala. In: 25th Kerala Science Congress. pp. 01-10.

Popular articles authored / co-authored in press and Magazines

B. Ajith Kumar, This month crop cultivation, *Karshakan* 2013-14 (In all issues)

Udaipur

Research papers:

Panchu, Ram., Solanki, N. S., Rakesh Kumar and Sumeriya, H. K. (2014). Influence of Fertility Levels and Foliar Sprays of Thiourea on Growth, Yield, Nutrient Uptake and Economics of Quality Protein Maize (Zea mays L.) under Southern Rajasthan Condition. Ann. Agri Bio Res., 19(2): 230-233.

Pushpendra, Singh., Sumeriya, H. K., Solanki, N. S., Ratnesh Kumar Dubey., Tiwari, R. C., Azad Murdia and Golada, S. L. (2013). Productivity and Economics of Elite Sorgham [Sorghum bicolor (L.) Moench] Genotypes as Influenced by Different Fertility Levels. Ann. Biol., 29(3): 311-316.

Sarita Muhal., Solanki, N. S., Singh, P and Shukla, K. B. (2014). Effect of salicylic acid on productivity and nutrient uptake of Brassica species under different planting durations. Afr. J. Agric. Res., 9(13): 1101-1106.

Taruna, A., Solanki, N. S and Nepalia, V. (2013). Effect of Weather and Nitrogen on Growth and Productivity of Wheat Varieties (Triticum aestivum L). Int. J. Agric. Med. Plants Res., 1(3): 16-23.

Taruna, A., Solanki, N. S., Sharma, S. K., Jajoria, D. K and Dotaniya, M. L. (2013). Phenology, growth and yield of wheat in relation to Agrometeorological indices under different sowing dates. Afr. J. Agric. Res.,. 8(49): 6366-6374.

Taruna, A., Solanki, N. S., Sharma, S. K and Sumeriya, H. K. (2014). Analysis of Wheat (Triticum aestivum L.) Cultivars under Different Sowing Dates and Nitrogen Levels. Ann. Biol., 30(2): 253-256.

Popular articles authored / co-authored in press and Magazines

मनीषा राणा एवं डॉ. एन. एस सोलंकी (2013) सरसो में एकीकृत कीट प्रबंधन, किसान इन्टरनेशनल, जुलाई, सितम्बर, अक्टुम्बर, दिसम्बर – 2013 (सयुक्तांक) चचण38.39

Pamphlets:

एन. एस. सोलंकी एवं एस. एल मून्दड़ा 2013. जलवायु अनुकूलित खेतीः आज की आवश्यकता

एन. एस. सोलंकी एवं एस. एल मून्दड़ा 2013. जलवायु परिवर्तन एंव कृषि रणनीतिया

Staff position at cooperating centers during 2013

Centre	Positions Sanctioned and Filled (F) / Vacant (V)					
	Agrome-teo-rologist	Junior Agrono-mist	Senior Technical Assistant	Meteo-rological Observer	Field As-sistant	Junior Clerk
Akola	F	–	–	F	F	–
Anand	F	F	V	F	F	F
Anantapur	V	F	F	F	F	F
Bangalore	F	V	F	F	F	F
Bhubaneshwar	F	–	–	V	F	–
Bijapur	F	–	–	F	V	–
Chatha/Jammu	F	–	–	F	F	–
Dapoli	F	–	–	F	F	–
Faizabad	F	F	F	F	F	F
Hisar	V	F	V	F	F	F
Jabalpur	V	F	F	V	F	V
Jorhat	F	–	–	V	F	–
Kanpur	F	–	–	F	F	–
Kovilpatti	F	F	F	F	F	F
Ludhiana	F	F	F	F	F	F
Mohanpur	F	F	F	F	F	F
Palampur	F	–	–	V	V	–
Parbhani	F	–	–	F	V	–
Raipur	F	–	–	F	V	–
Ranchi	F	F	F	F	F	F
Ranichauri	V	V	V	F	F	F
Samastipur	F	–	–	V	F	–
Solapur	F	V	F	F	V	V
Thrissur	F	–	–	V	F	–
Udaipur	F	–	–	F	V	–
Total posts sanctioned	**25**	**12**	**12**	**25**	**25**	**12**
Total posts filled	**21**	**10**	**9**	**19**	**19**	**10**

F= Filled, V= Vacant

All India Coordinated Research Project on Agrometeorology

Centre-wise and Head-wise RE allocation (Plan) for the year 2013-14

(in Rupees)

Sl. No	Name of the center	Pay & allow.	TA	RC	NEH	TSP (100 %)			Total ICAR Share
						Works/ Contin-gency	Equip	IT	
1	Akola	1600000	20000	100000		0	0	0	1720000
2	Anand	2180000	30000	120000		0	0	0	2330000
3	Anantapur	1650000	30000	120000		0	0	0	1800000
4	Bangalore	3600000	35000	120000		0	0	0	3755000
5	Bhubane-swar	1400000	30000	120000		1550000	400000	150000	3650000
6	Bijapur	1620000	20000	120000		0	0	0	1760000
7	Chatha	1200000	30000	120000		0	0	0	1350000
8	Dapoli	1900000	25000	100000		0	0	0	2025000
9	Faizabad	2700000	50000	120000		0	0	0	2870000
10	Hisar	2000000	30000	100000		0	0	0	2130000
11	Jabalpur	1500000	30000	100000		700000	350000	100000	2780000
12	Jorhat	1800000	30000	100000	1500000	1300000	200000	200000	5130000
13	Kanpur	2000000	25000	100000		0	0	0	2125000
14	Kovilpatti	2600000	35000	100000		0	0	0	2735000
15	Ludhiana	3235000	30000	120000		0	0	0	3385000
16	Mohanpur	2400000	30000	100000		0	0	0	2530000
17	Palampur	1800000	20000	100000		400000	375000	100000	2795000
18	Parbhani	1500000	25000	100000		0	0	0	1625000
19	Raipur	1800000	30000	120000		1500000	400000	100000	3950000
20	Ranchi	3200000	30000	100000		700000	0	50000	4080000
21	Ranichauri	200000	20000	100000		0	0	0	320000
22	Samastipur	1370000	30000	100000		0	0	0	1500000
23	Solapur	2080000	40000	120000		750000		125000	3115000
24	Thrissur	1265000	25000	180000		0	0	0	1470000
25	Udaipur	2400000	20000	100000		100000	375000	75000	3070000
	Total	**490,00,000**	**7,20,000**	**27,80,000**	**15,00,000**	**70,00,000**	**21,00,000**	**9,00,000**	**640,00,000**


WORKING GROUP MEETING
ALL INDIA COORDINATED RESEARCH PROJECT ON AGROMETEOROLOGY
November 11-13, 2013
Organized by
Assam Agricultural University, Jorhat
Indian Council of Agricultural Research, New Delhi
ICAR


WORKING GROUP MEETING
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All India Coordinated Research Project on Agrometeorology
SERB School on
"Agrometeorological Aspects of Extreme Weather Events"
1 - 21 May, 2013


Customized Training Program
for AIC Officers on Agrometeorology
11 - 15 August 2014