

Crop modelling applications in climatic risk management

Pramod Aggarwal

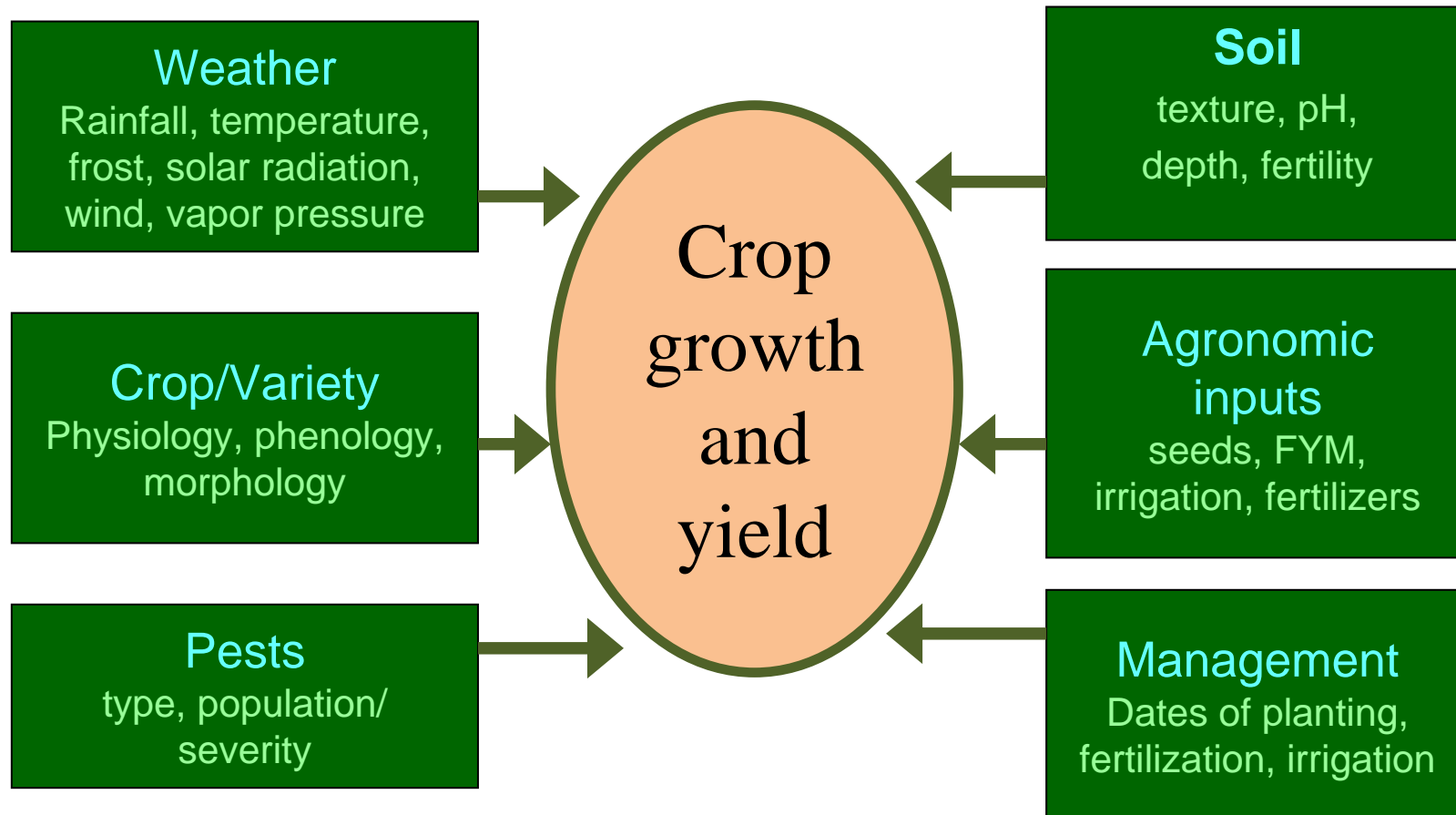
**CGIAR Research Program on
Climate Change, Agriculture and Food Security,
International Water Management Institute**

Weather derivatives based insurance

1. Yield loss due to weather deviation (vulnerability)
2. Probability of weather deviation (frequency)
3. Weather risk = vulnerability * frequency
4. Financial aspects: converting weather risk to payouts and premiums

Crop-weather relationship:

Need to understand all major crop yield regulating factors



Methods to understanding the impact of weather on crops

- Observations in farmers' fields**
- Experiments on research farm**
- Controlled environment experiments**
- Statistical relationships**
- Analogues**
- Crop growth simulation models**

Assessing vulnerability of Indian agriculture to climate change:
Controlled environment facilities at IARI, Delhi



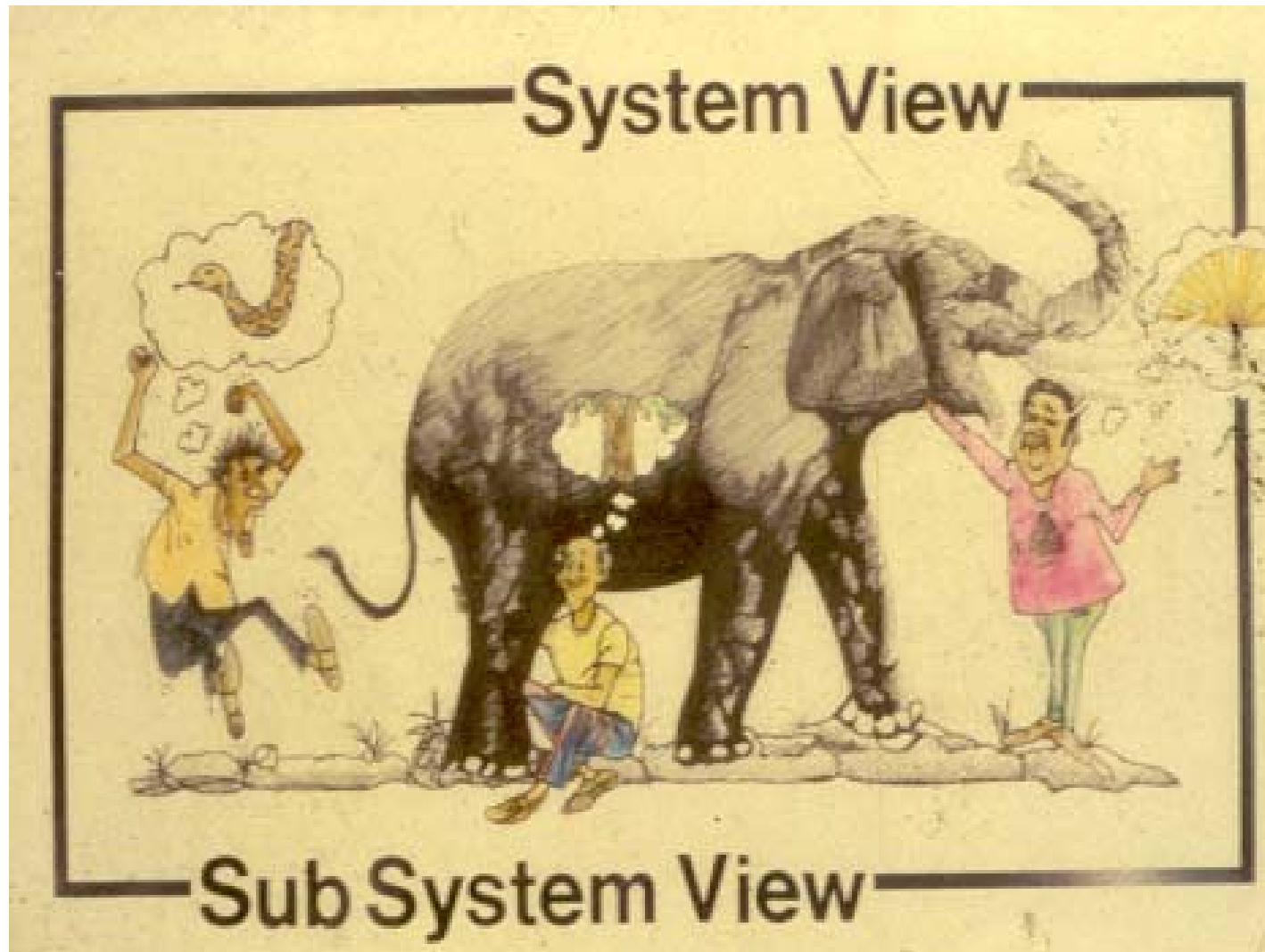
Crop loss due to climatic extremes/deviations

- **Crop loss due to rainfall/temperature stress**
 - **Stress at different periods during crop season**
 - **Stress at different crop development stages**
 - **Stress of different intensities**
 - **Stress at different locations**
 - **Base weather**
 - **Different years/seasons**
 - **Soils**
 - **Varieties**
 - **Planting dates**
 - **Fertilizers**
 - **Irrigation**

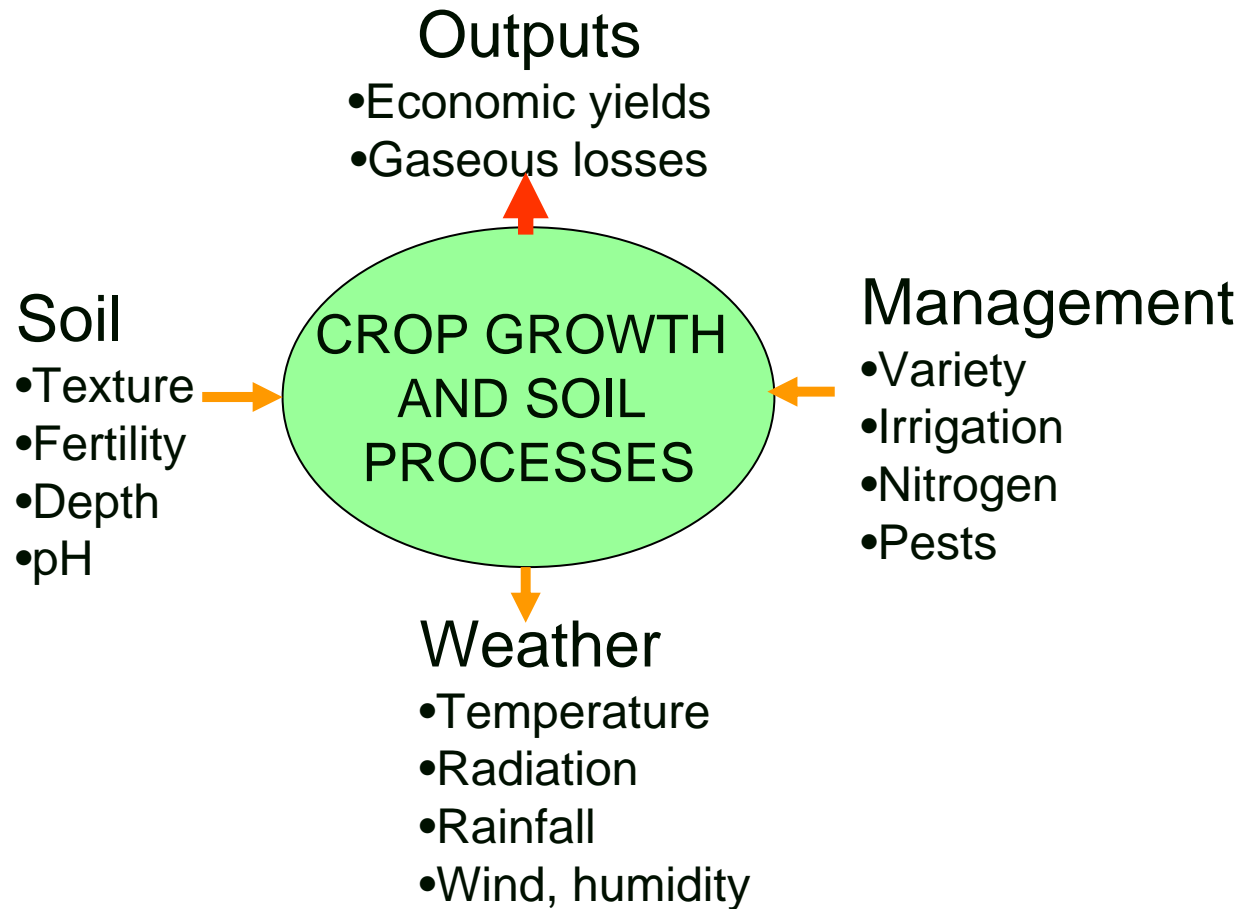
Crop Growth Simulation Models

- Understand/ predict behavior of crops on the basis of quantitative understanding of **processes** from experiments in field and controlled environments
- Integrate spatial and temporal variability in soil, weather, crop, pests and management factors
- Not location specific: can be used in any site with minimum soil, plant and weather data
- Testable via field experimentation

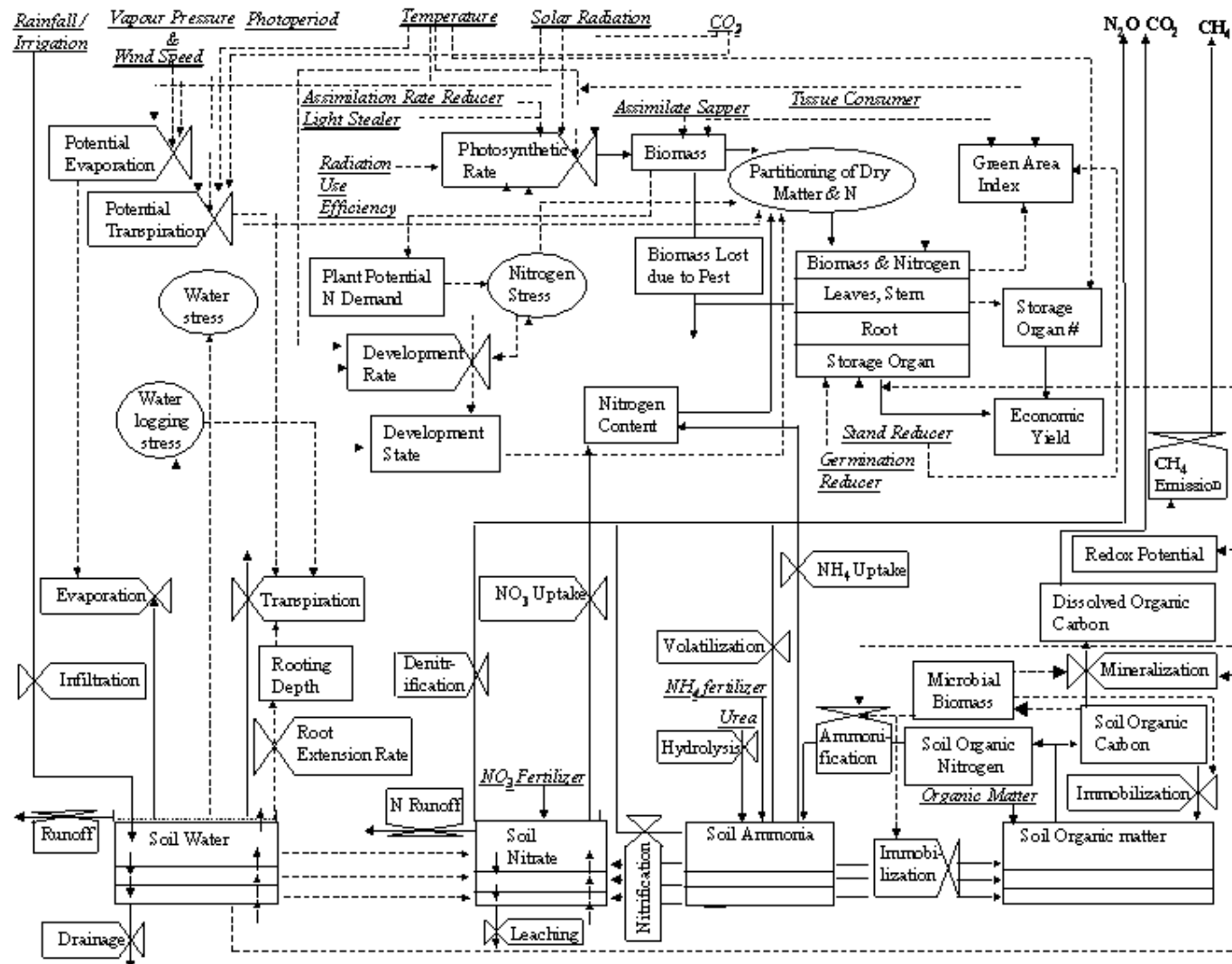
Crop modelling facilitates knowledge integration



InfoCrop: A crop growth model to simulate the impact of regulating factors on crop yield



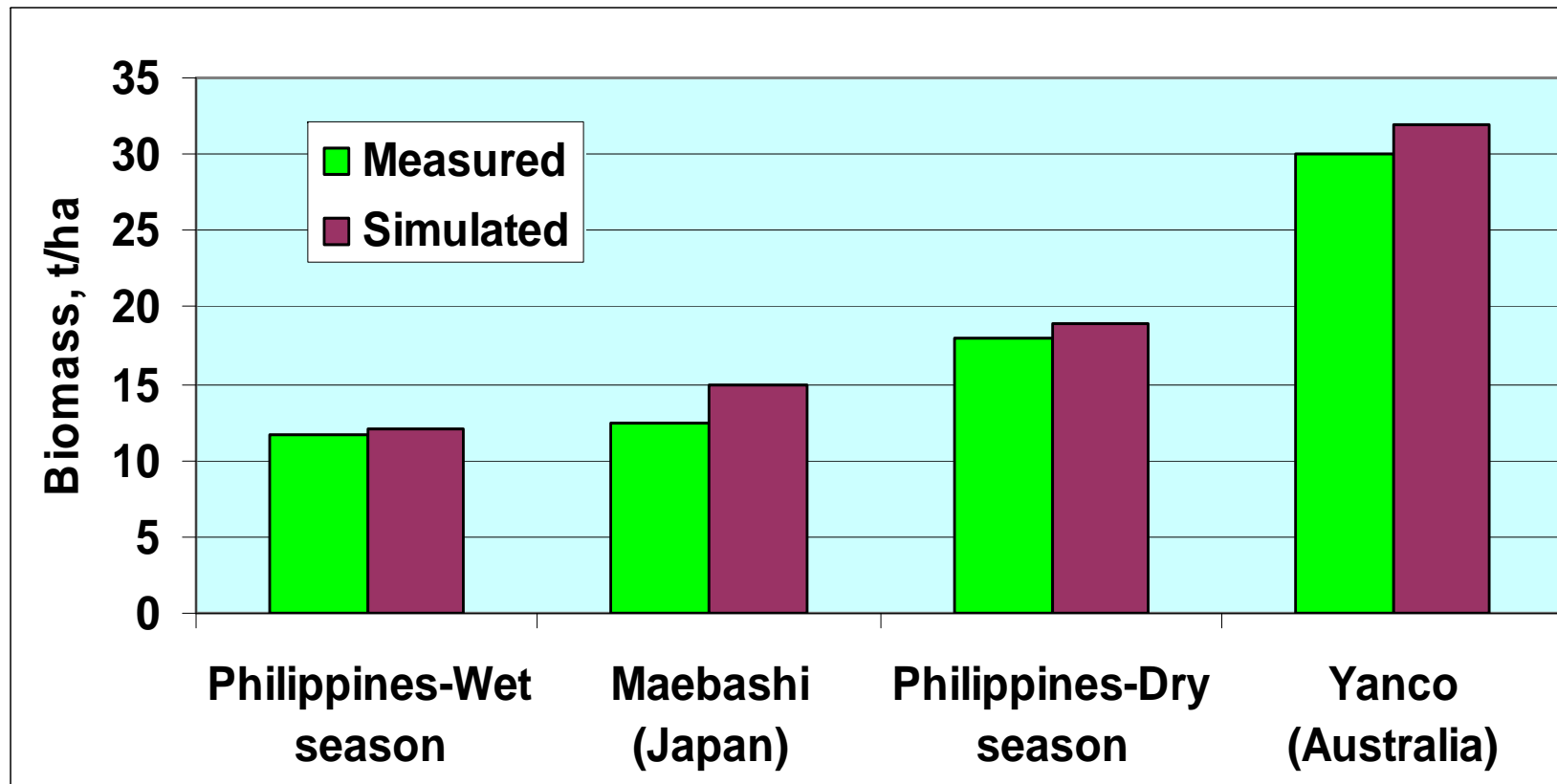
Process-based simulation models



InfoCrop- A User-friendly System for Applications of Crop Models

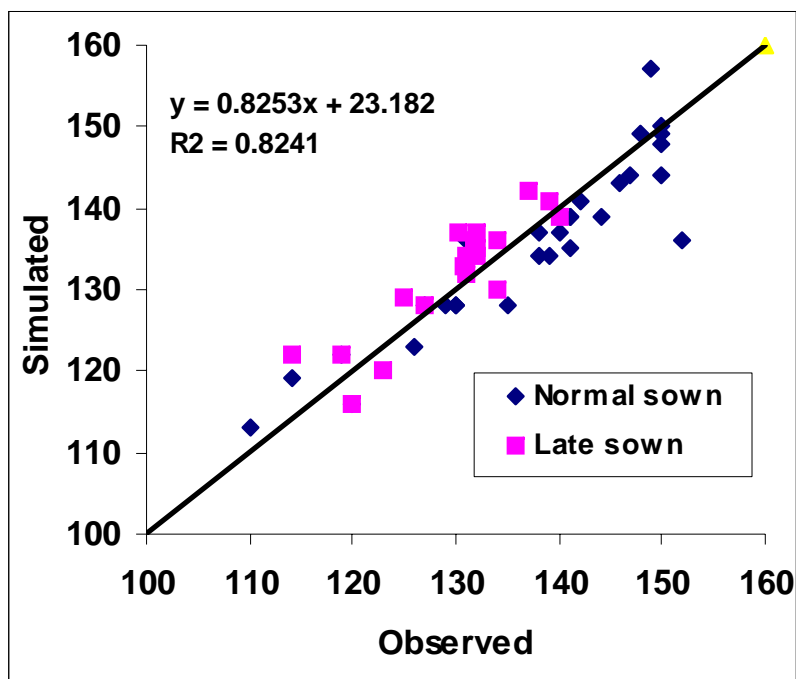


Validation of Rice model-ORYZA- in Contrasting Agro-Environments

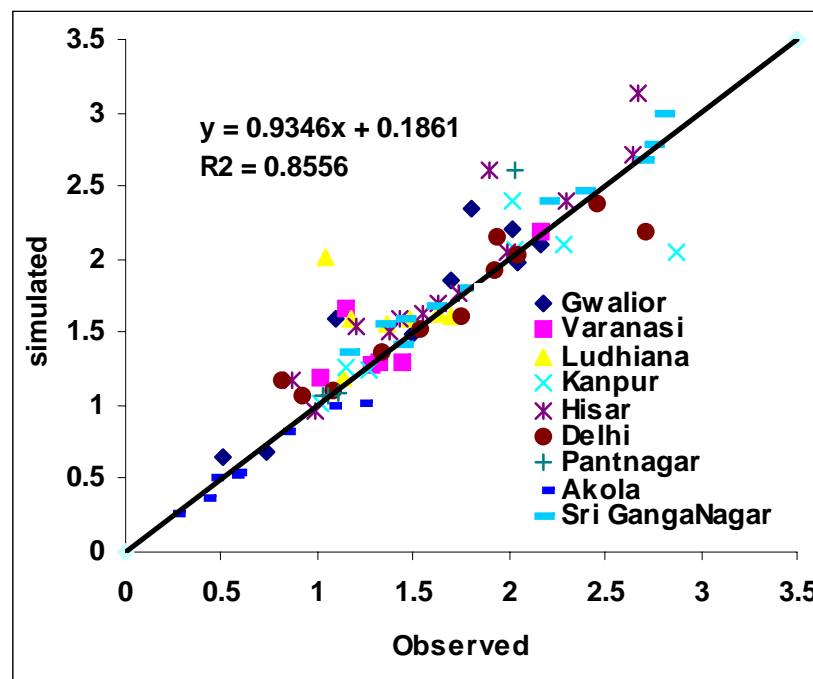


InfoCrop: Validation for mustard in major agro-environments

Days to maturity



Grain yield, tons/ha



Simulation Models: Decision Support Tools in Crop Insurance

Planning

- **Characterization of risk profile of different regions and crops for designing policies**

Monitoring

- **Assessment of loss and its forewarning**

Settlement

- **Quick settlement of disputed claims: reconstructing past**

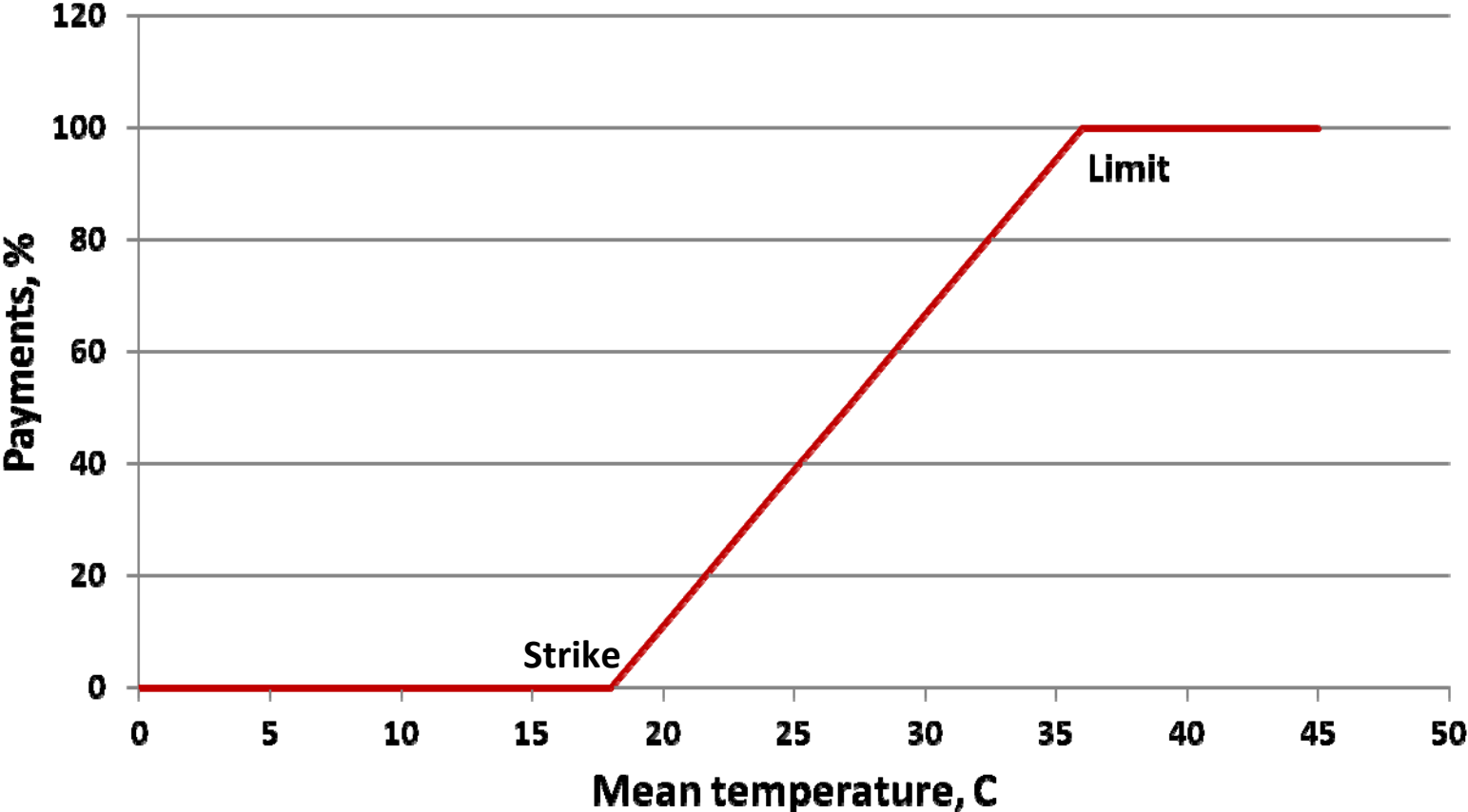
Approach to quantify yield loss due to weather deviation

- **Goal:** Define crop loss in a stress period
- **Inventory of data:** Crop acreage, soils, varieties, base weather
- **Technology:** Irrigated/rainfed, fertilizer level
- **Management:** Planting date, variety, typical input schedules
- **Information processing:** InfoCrop
- **Value –addition:** Post-processing and expert evaluation
- **Output:** Yield loss due to weather deviation

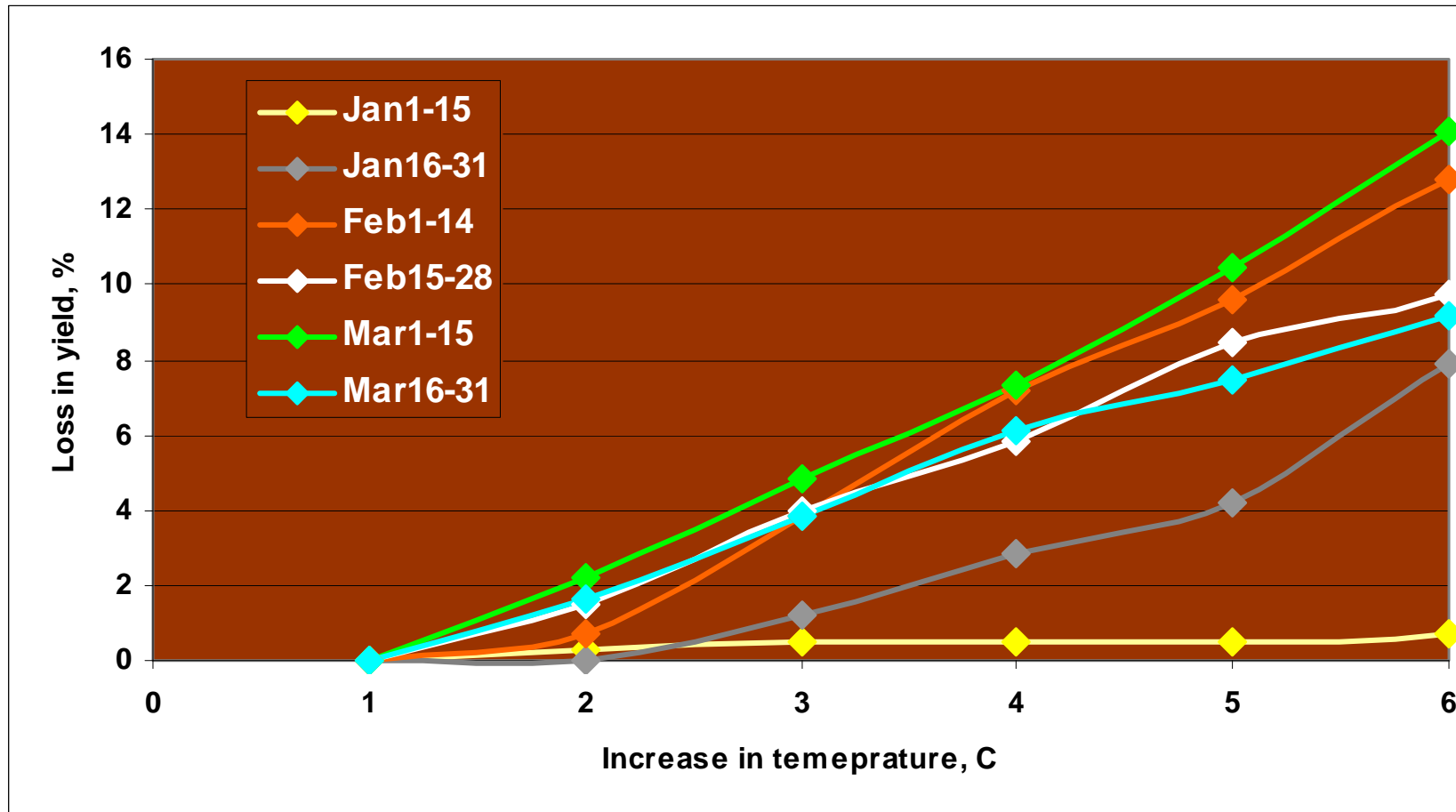
Indices to characterize temperature stress

- **Mean temperature deviation**
- **Cumulative temperature deviation**
- **Canopy temperatures**
- **Plant water stress**
- **Thermal images of canopies**
- **NDVI**

Temperature insurance



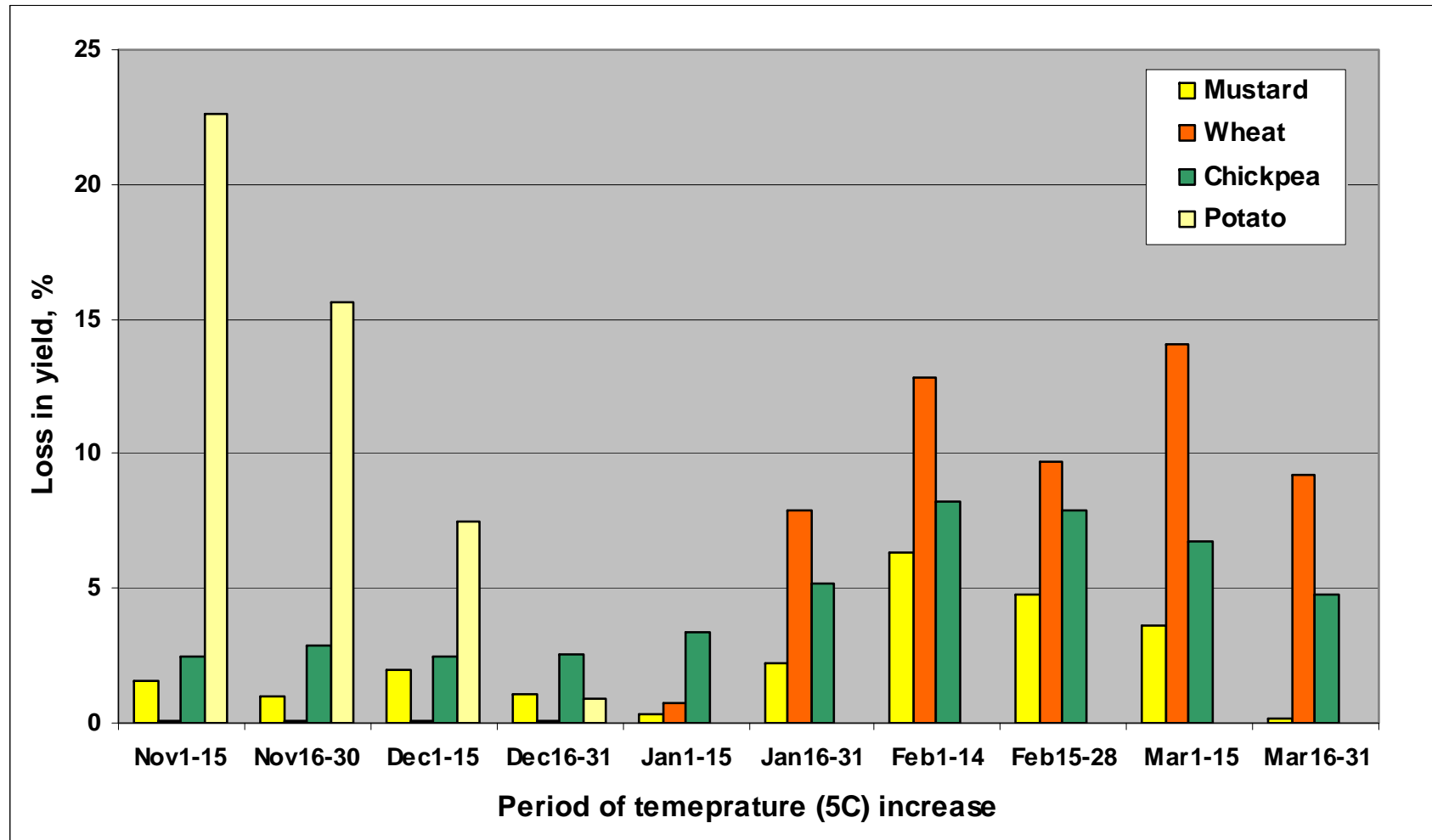
Loss in wheat yield with increase in temperature at different times



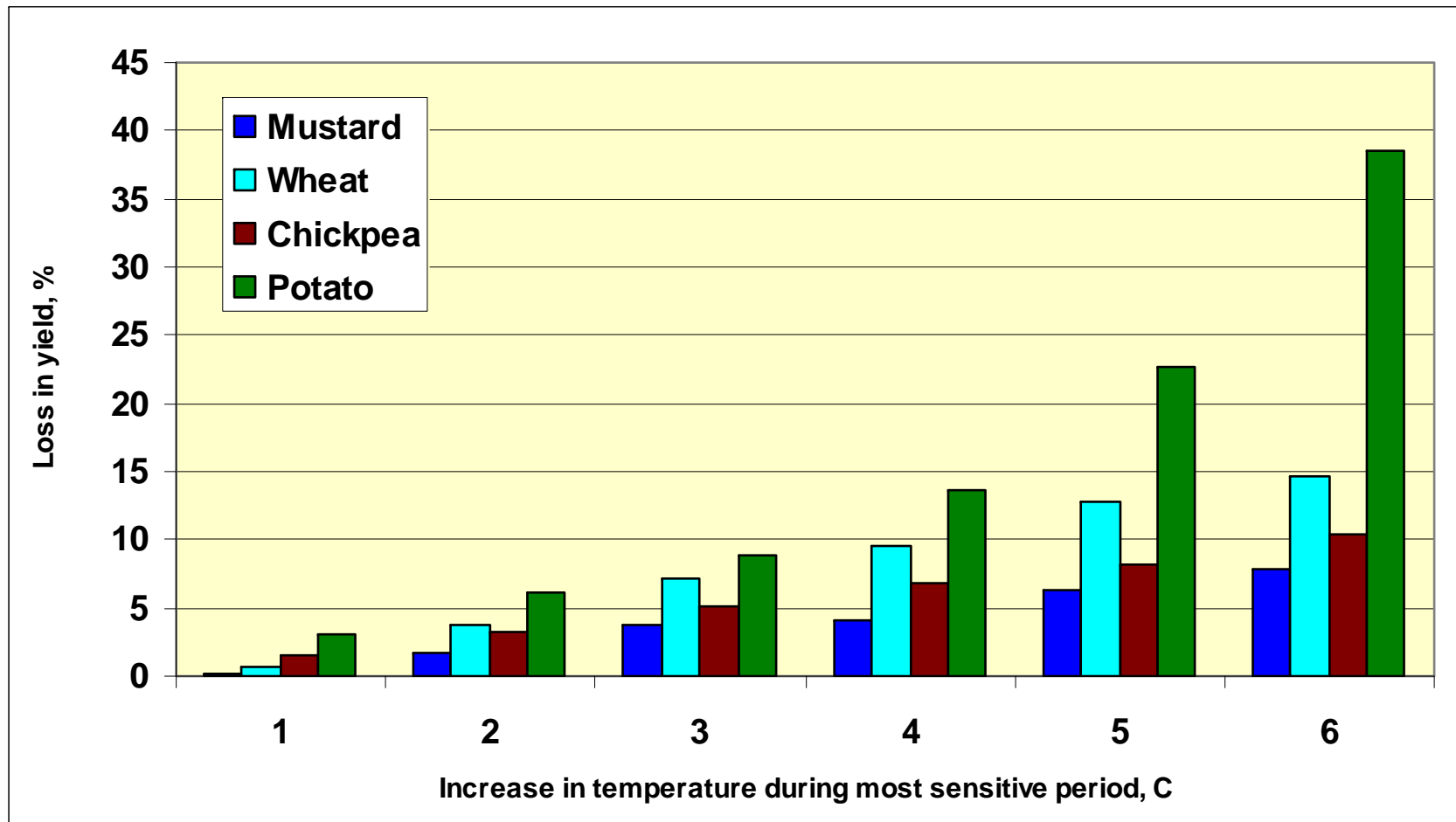
Magnitude of crop loss in wheat at different stages due to increase in temperature

Increase in temperature, C	Period of increase in temperature	Punjab	Haryana	West UP	North Rajasthan	South Rajasthan	West MP	East UP
1	Jan1-15	0.0	0.3	0.2	0.0	0.1	1.3	1.0
2	Jan1-15	0.0	0.5	1.2	0.1	2.7	5.0	3.5
3	Jan1-15	0.0	0.5	2.5	1.8	7.4	6.7	6.0
4	Jan1-15	0.0	0.5	4.3	2.4	9.3	10.0	8.6
5	Jan1-15	0.0	0.7	6.1	4.7	14.0	13.7	11.9
6	Jan1-15	0.0	2.1	9.1	6.6	17.3	18.1	15.8
1	Jan16-31	0.0	0.0	0.8	0.0	0.3	0.8	0.9
2	Jan16-31	0.0	1.2	2.4	0.3	3.2	3.4	1.5
3	Jan16-31	0.6	2.8	4.9	1.8	6.9	4.4	4.5
4	Jan16-31	2.3	4.2	9.1	4.0	7.9	7.9	6.2
5	Jan16-31	2.7	7.9	10.9	5.7	10.7	12.7	7.8
6	Jan16-31	5.3	10.6	13.2	7.0	15.7	17.1	12.5
1	Feb1-14	0.0	0.7	0.5	0.7	1.2	0.4	1.3
2	Feb1-14	1.4	3.8	0.9	1.2	2.6	1.6	2.9
3	Feb1-14	3.5	7.2	2.8	1.7	4.6	2.3	5.3
4	Feb1-14	7.2	9.6	5.5	3.5	7.2	4.5	8.6
5	Feb1-14	10.4	12.8	7.9	4.9	10.6	7.8	12.1
6	Feb1-14	12.7	14.7	9.8	9.2	16.2	11.3	16.9
1	Feb15-28	0.1	1.5	2.0	1.7	2.3	0.8	2.7
2	Feb15-28	0.9	4.0	4.3	3.8	5.1	1.7	6.3
3	Feb15-28	2.2	5.8	7.2	6.8	8.2	3.9	9.3
4	Feb15-28	4.5	8.5	10.7	9.9	11.5	5.5	12.8
5	Feb15-28	7.1	9.7	14.5	12.7	14.7	7.4	14.8
6	Feb15-28	8.5	12.6	18.7	15.2	17.5	9.0	16.9
1	Mar1-15	1.2	2.2	2.2	2.1	1.0	0.7	0.9
2	Mar1-15	2.6	4.8	4.6	4.3	1.7	1.3	2.1
3	Mar1-15	4.8	7.3	7.2	6.6	2.3	2.1	3.0
4	Mar1-15	6.9	10.5	9.4	8.4	3.7	2.5	3.4
5	Mar1-15	9.5	14.1	11.8	9.5	4.1	3.4	4.4
6	Mar1-15	14.2	17.7	13.6	10.8	4.5	4.0	4.9
1	Mar16-31	1.7	1.6	0.2	0.2	0.0	0.3	0.0
2	Mar16-31	4.6	3.8	0.9	1.0	0.0	0.7	0.0
3	Mar16-31	7.2	6.1	1.0	1.2	0.0	1.3	0.0
4	Mar16-31	10.0	7.5	1.5	1.4	0.0	1.8	0.0
5	Mar16-31	12.4	9.2	1.7	1.7	0.0	2.3	0.0
6	Mar16-31	14.2	10.5	1.9	2.0	0.0	2.8	0.1

Sensitivity of different crops to increase in temperature at different times



Relative sensitivity of different crops to increase in temperature at a given time



Yield loss due to adverse weather

- **High temperature**
- **Frost**
- **Fog**
- **Deficit/Excessive/un-seasonal rainfall**

Applications of crop-climate models in agriculture

Real-time

- Regional estimates of anticipated crop production
- Farm agro-advisories

Strategic Planning

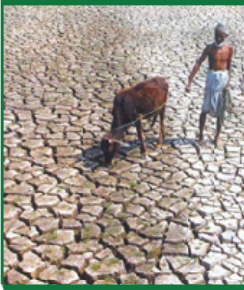
- Climatic risk assessment for crop insurance
- Impact assessment of climate change
- Strategic planning for development
- Hybrid seed production

Climate smart agriculture for managing risks

CLIMATE SMART VILLAGE / FARM

Weather smart

- Seasonal weather forecasts
- ICT based agro-advisories
- Index based insurance
- Climate analogues



Water smart

- Aquifer recharge
- Rainwater harvesting
- Community management of water
- Laser leveling
- On-farm water management



Carbon smart

- Agroforestry
- Conservation tillage
- Land use systems
- Livestock management



Nitrogen smart

- Site specific nutrient management
- Precision fertilizers
- Catch cropping / legumes



Energy smart

- Biofuels
- Fuel efficient engines
- Residue management
- Minimum tillage



Knowledge smart

- Farmer-farmer learning
- Farmer networks on adaptation technologies
- Seed and fodder banks
- Market info
- Off-farm risk management-kitchen garden

