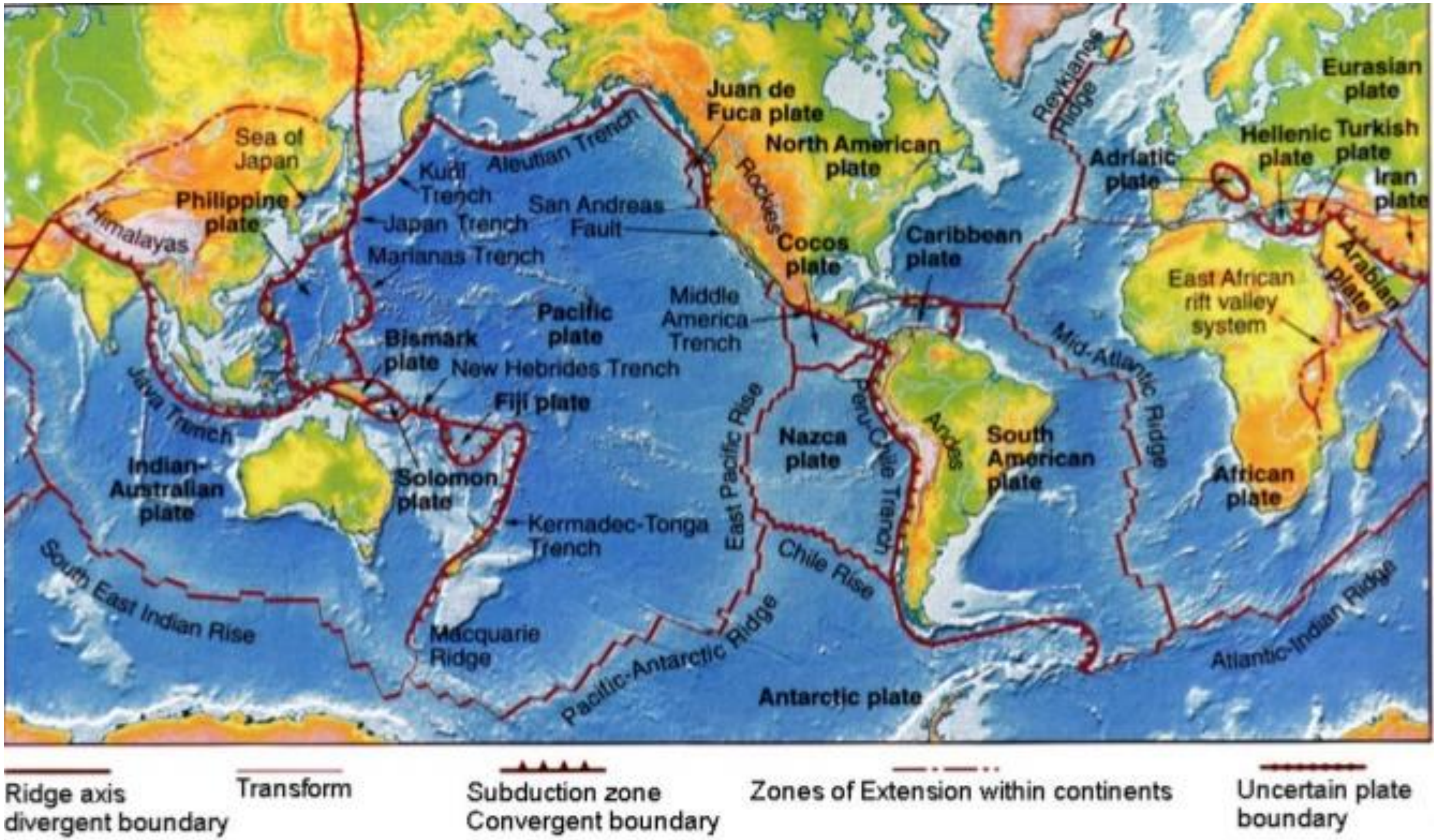
Resilience of Coastal Biodiversity Towards Climate Change

Prof. A. B. Das
Emeritus Professor, Department of Botany,
Utkal University, Bhubaneswar
E-mail: abdas.uubot@gmail.com

Primordial Soup

- Assumes ancient earth atmosphere of ammonia, hydrogen, methane and water vapor – volcano-like environments
- Lightning striking methane gas could form organic compounds – Amino acids, ATP, sugar and nitrogen bases synthesized form cyanide in lab exiuipments
- These simple molecules could arrange themselves into small, single-stranded strips of RNA which in turn produce DNA
- Early atmosphere now believed to contain CO_2 & O_2 and 2^{nd} law of Thermodynamics (entropy) – are big questions

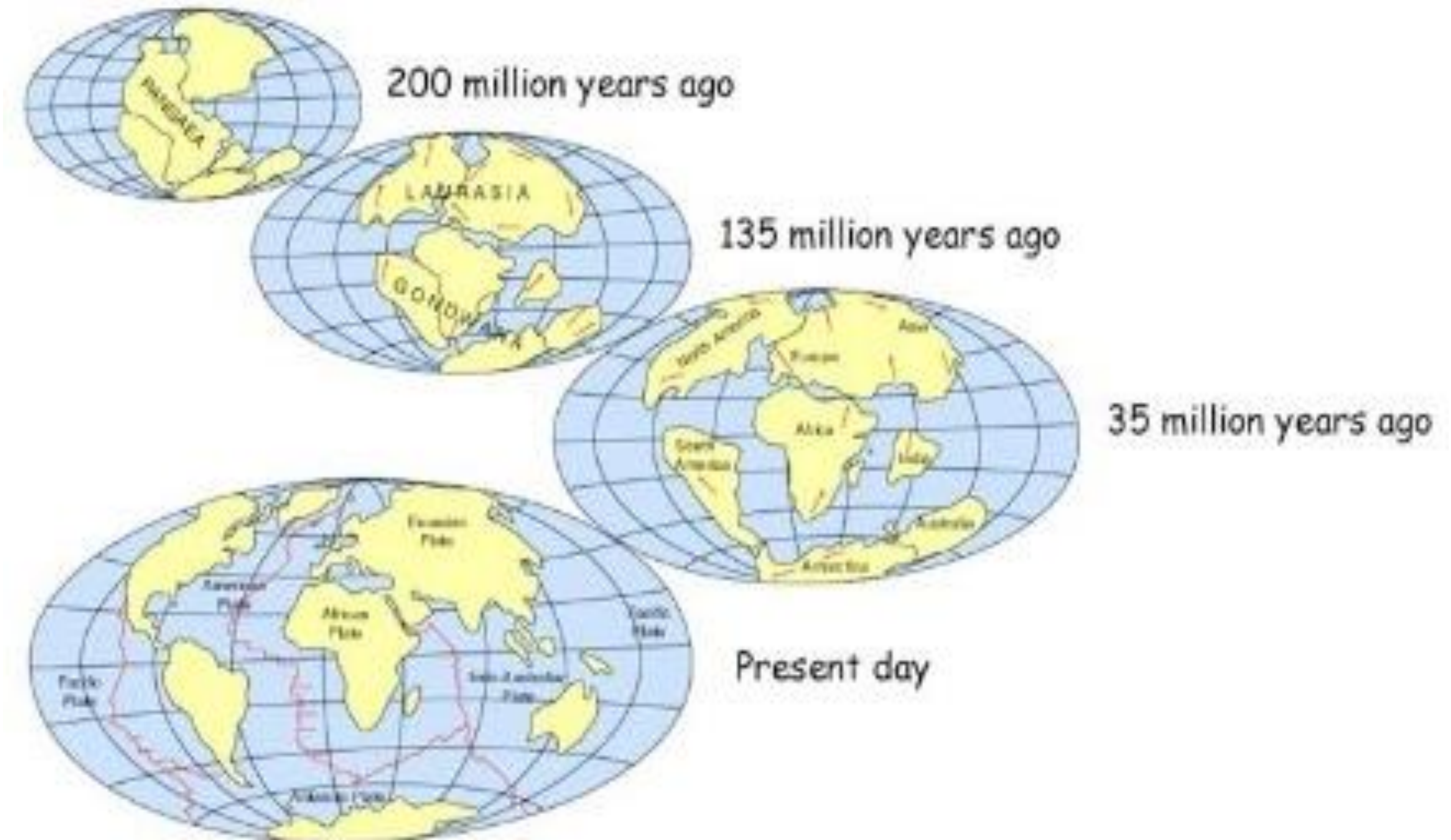
Earth Plate



Eurasian plate
Juan de Fuca plate
North American plate
Sea of Japan
Aleutian Trench
Kuril Trench
Philippine plate
Himalayas
Japan Trench
San Andreas Fault
Rockies
Cocos plate
Caribbean plate
Reykjanes Ridge
Adriatic plate
Hellenic plate
Turkish plate
Iran plate
Arabian plate
East African rift valley system
Marianas Trench
Pacific plate
Middle America Trench
Bismark plate
New Hebrides Trench
Fiji plate
Java Trench
Indian-Australian plate
Solomon plate
Kermadec-Tonga Trench
East Pacific Rise
Nazca plate
Peru-Chile Trench
Andes
South American plate
Mid-Atlantic Ridge
African plate
Chile Rise
South East Indian Rise
Macquarie Ridge
Pacific-Antarctic Ridge
Antarctic plate
Atlantic-Indian Ridge
Ridge axis divergent boundary
Transform
Subduction zone Convergent boundary
Zones of Extension within continents
Uncertain plate boundary

Continental Drift

Earth Originated from **Pangaea**



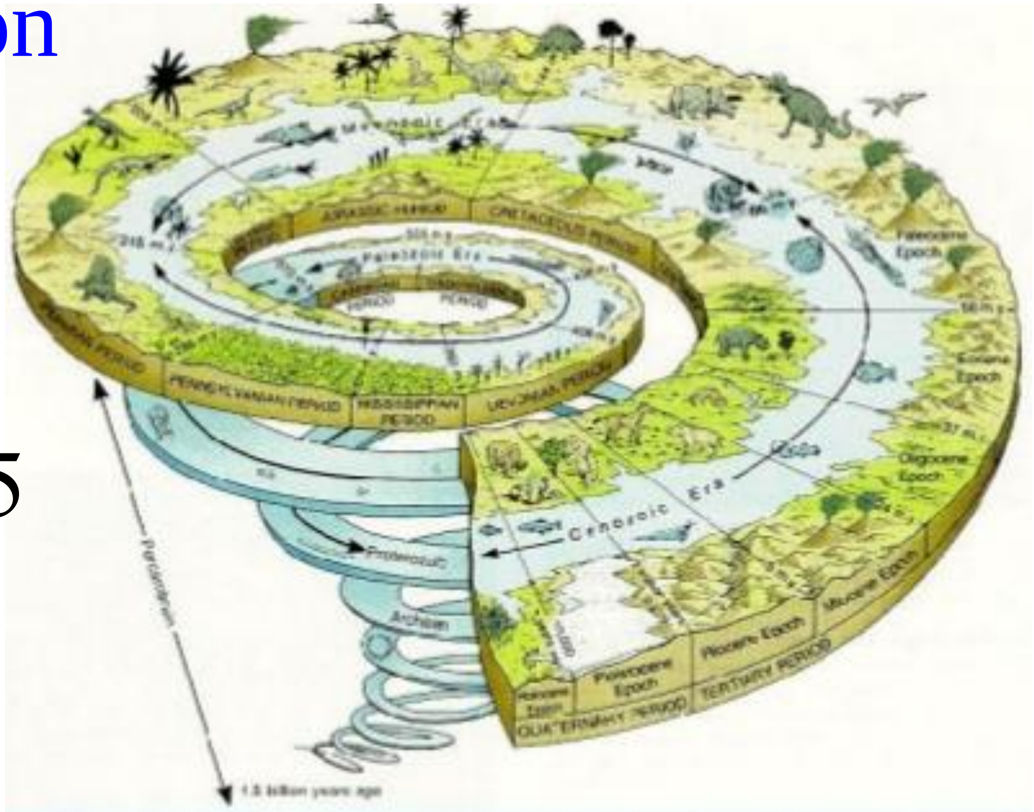
Age of the Earth: Evolution

Humans began to evolve 1.4 million years ago

Fish were seen about 500 million years ago

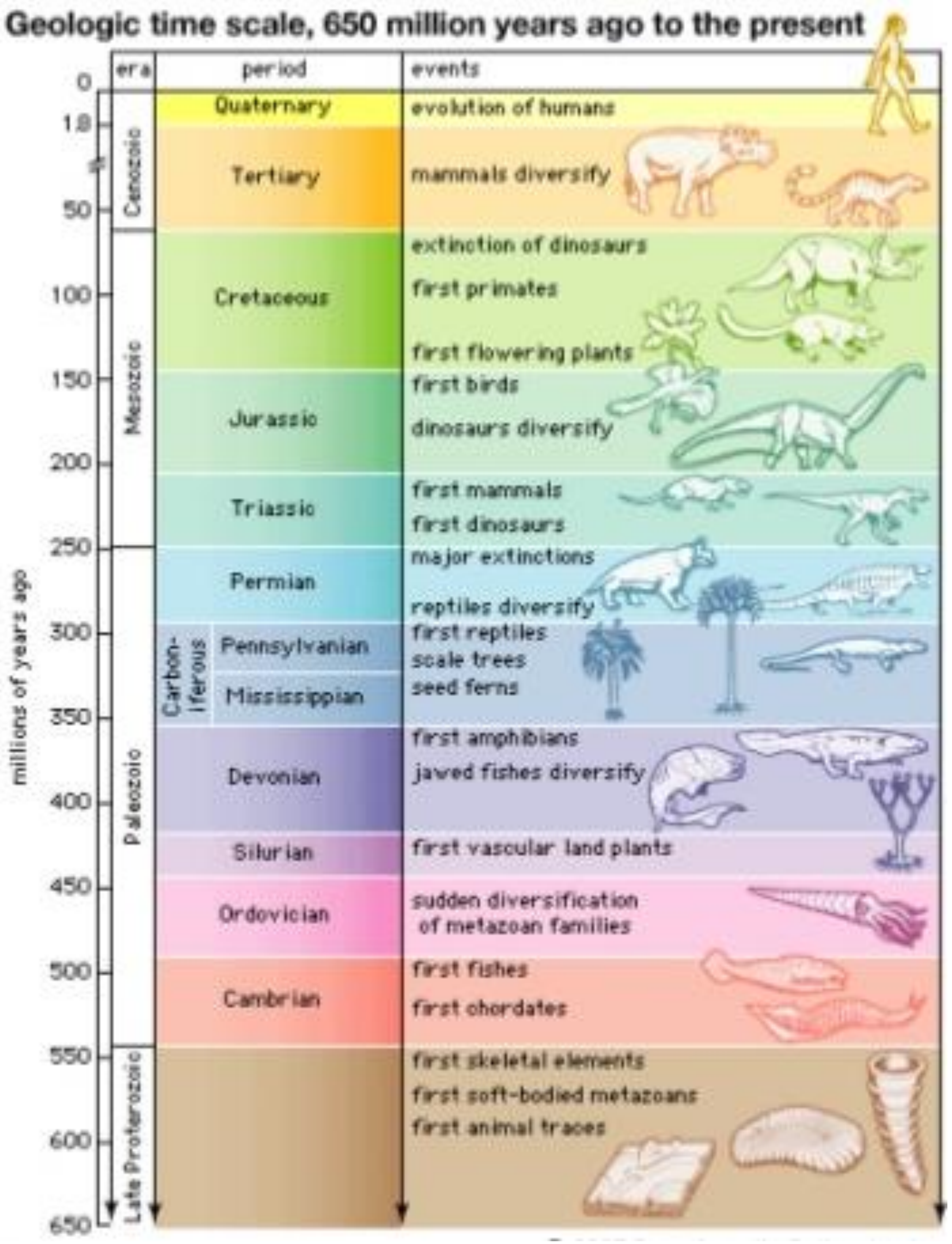
Earth’s first life forms appeared 3.5 billion years ago.

Our planet is roughly 4.6 billion years old.



Geographical Time Scale

Earth Age is about 4.6 Billion years

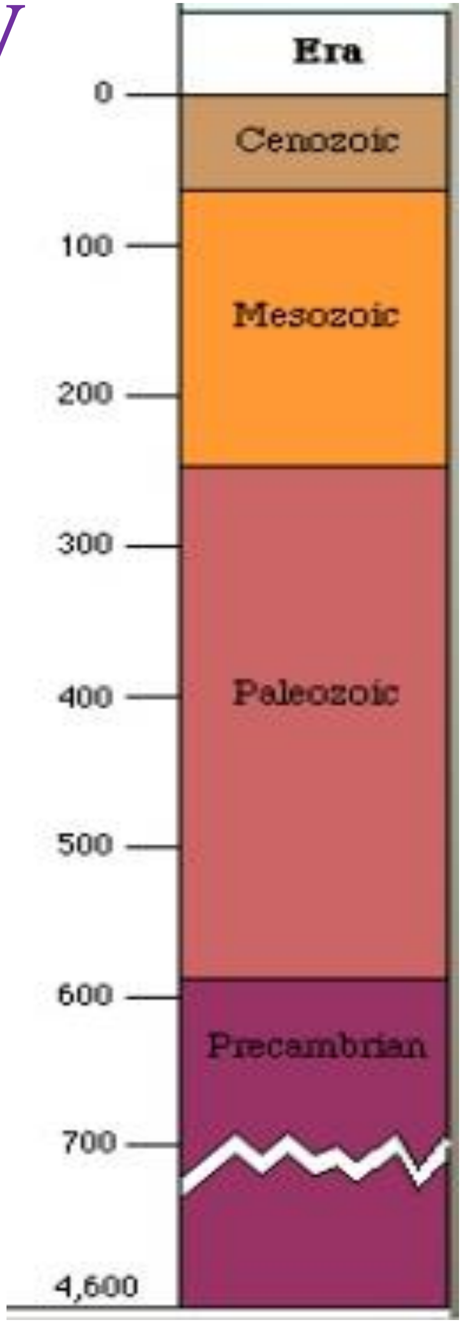


Major Eras in Earth's History

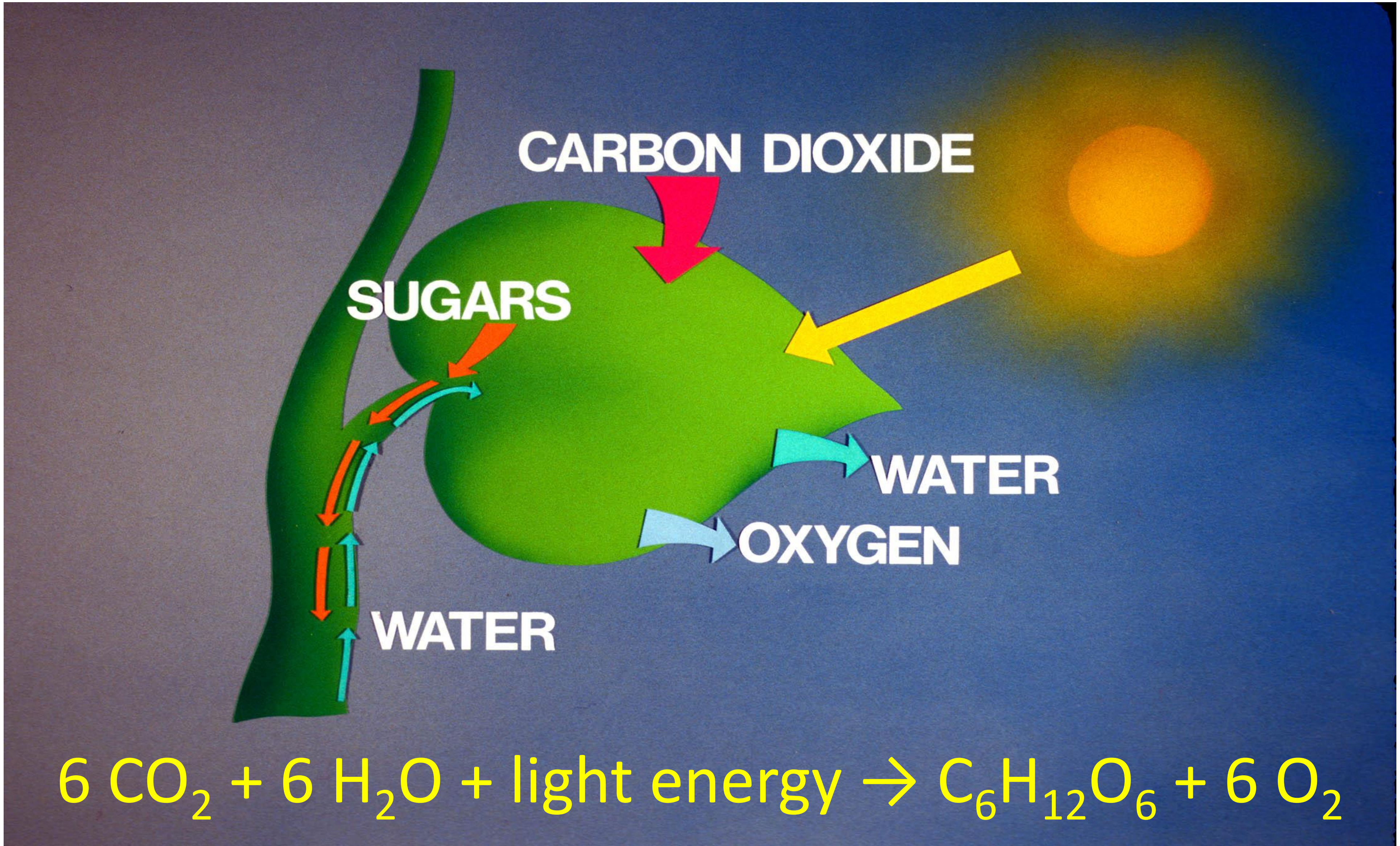
- Archean (460 mya – 2500 mya)
- Proterozoic (2500 mya – 540 mya)
- Paleozoic (540 mya -250 mya)
- Mesozoic (250 mya – 65.5 mya)
- Cenozoic (65.5 mya – present)

- Cenozoic era divided in to Tertiary and Quarterny.

- Development of modern mammals, angiosperms and human beings.



Light Energy Harvested by Plants & Other Photosynthetic Autotrophs

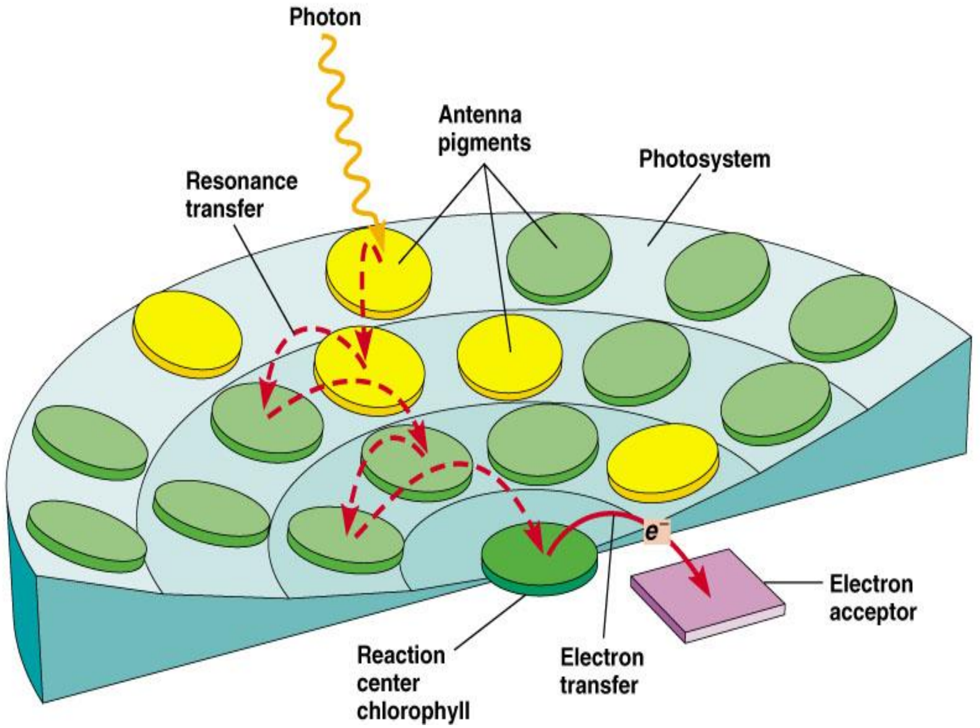


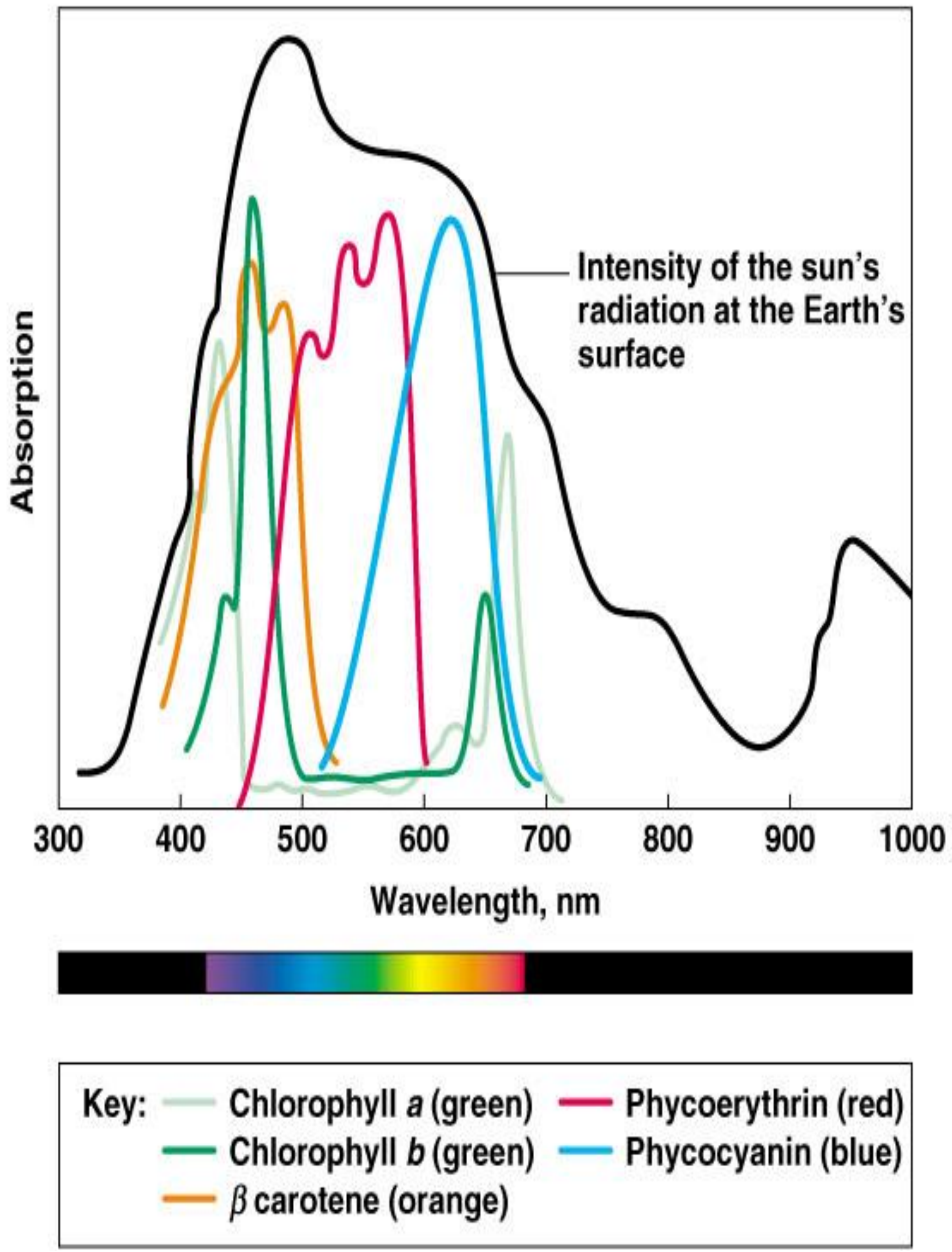
$$6\ CO_2 + 6\ H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6\ O_2$$

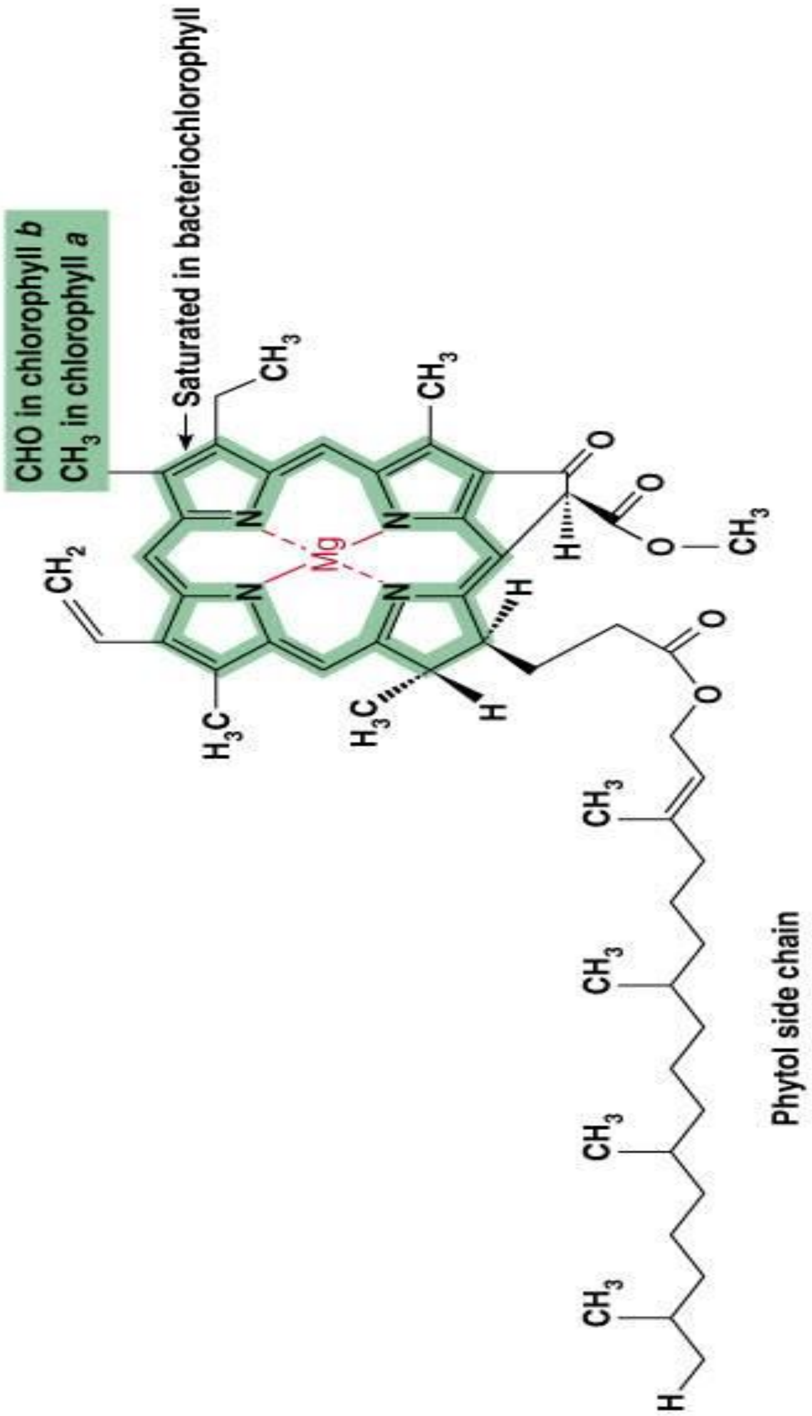
Growth development and morphogenesis

external appearance of plant life

Material and energy transformation basis for growth and development

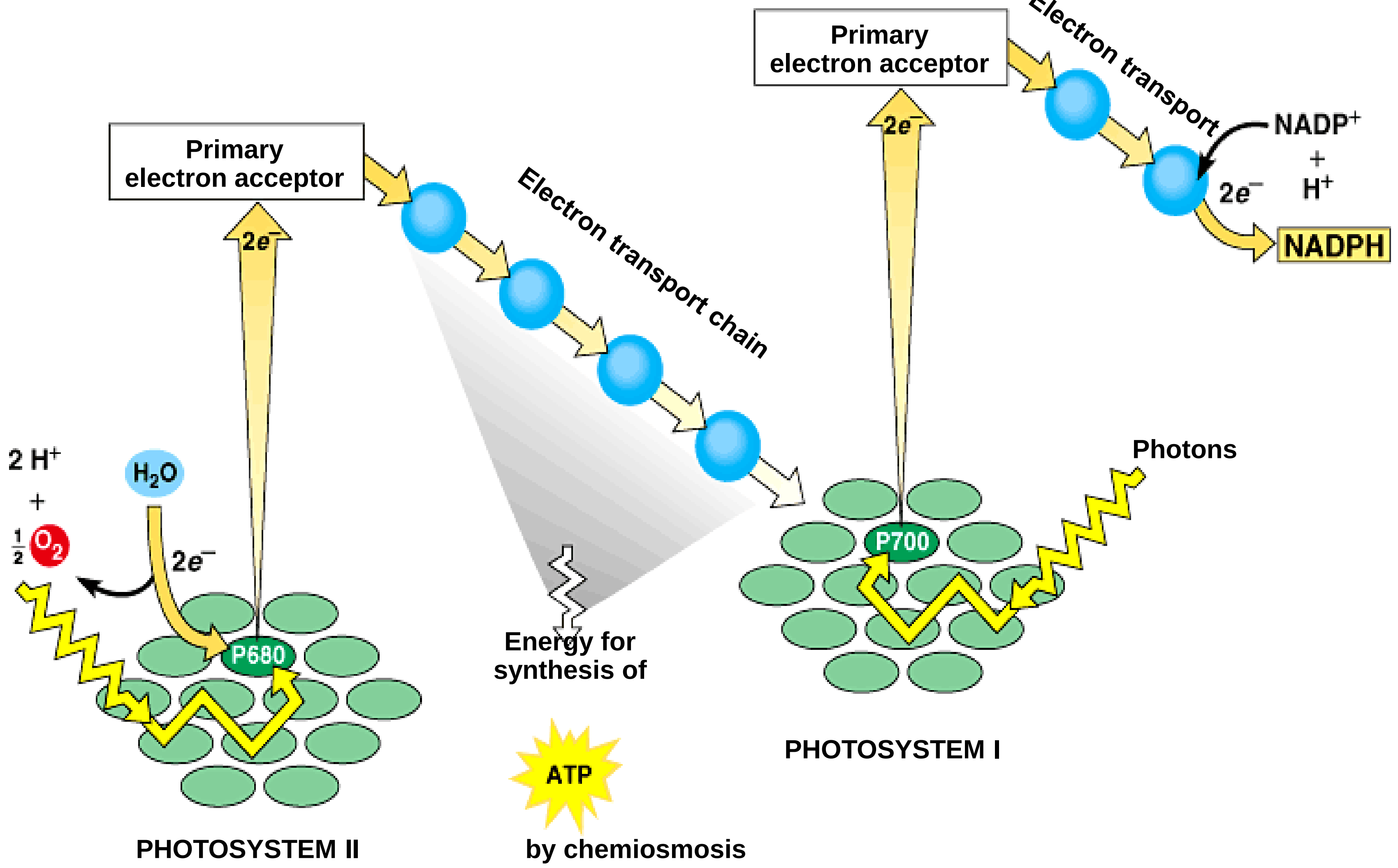



Absorption
Intensity of the sun's radiation at the Earth's surface
300
400
500
600
700
800
900
1000
Wavelength, nm
Key:
Chlorophyll a (green)
Chlorophyll b (green)
β carotene (orange)
Phycoerythrin (red)
Phycocyanin (blue)

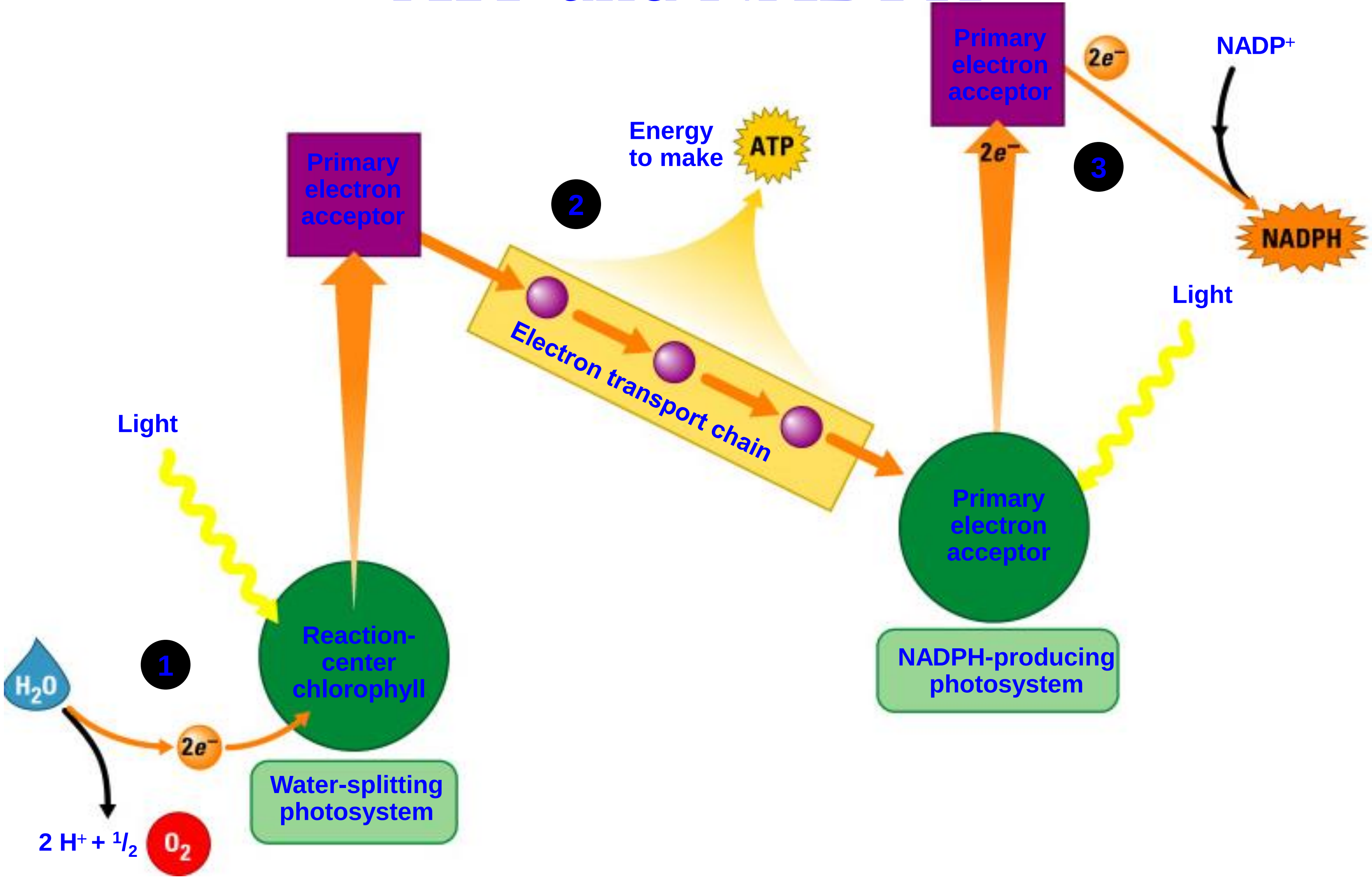

Saturated in bacteriochlorophyll
CHO in chlorophyll b
CH3 in chlorophyll a
Mg
Phytol side chain

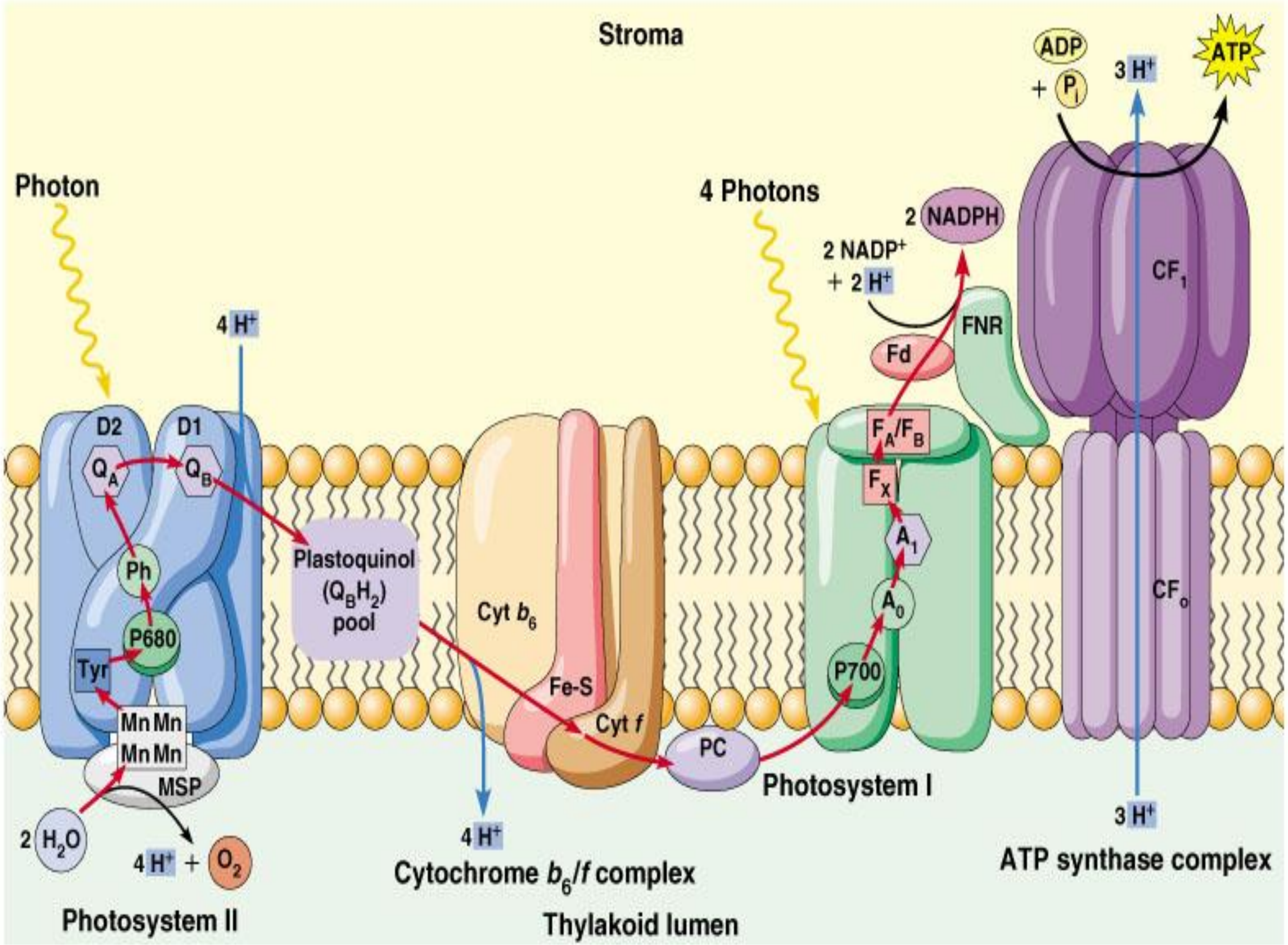
Noncyclic Photophosphorylation

- Photosystem II regains electrons by splitting water, leaving O_2 gas as a by-product



How the Light Reactions Generate ATP and NADPH





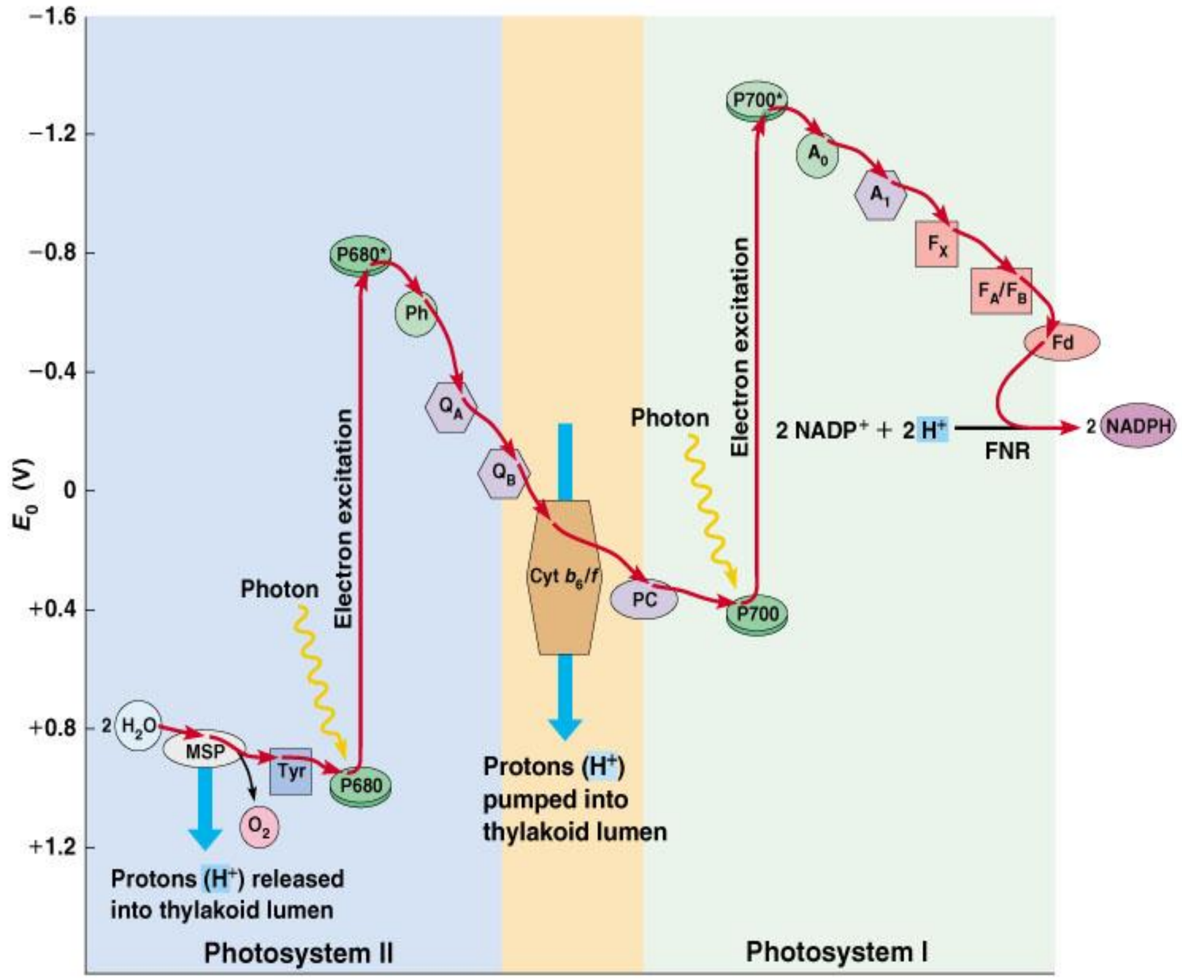
Stroma
Photon
4 Photons
ADP
+ P_i
3 H^+
ATP
2 NADPH
2 $NADP^+$
+ 2 H^+
FNR
Fd
CF_1
4 H^+
D2
D1
Q_A
Q_B
F_A/F_B
F_X
A_1
A_0
Ph
P680
Tyr
Plastoquinol
(Q_BH_2)
pool
Cyt b_6
Fe-S
Cyt f
P700
CF_o
Mn Mn
Mn Mn
MSP
PC
Photosystem I
2 H_2O
4 H^+ + O_2
4 H^+
3 H^+
Photosystem II
Cytochrome b_6/f complex
Thylakoid lumen
ATP synthase complex

Plants produce O_2 gas by splitting H_2O

The O_2 liberated by photosynthesis is made from the oxygen in water (H^+ and e^-)

Basics of life

Message transportation and signal transduction important part of plant adaptation to the environment.



Stress

Environmental damage to plants

Biotic stress Abiotic stress

Resistance

The adaptability of plants to adverse environment

Stress avoidance or

Stress tolerance

Stress Physiology

Adversity makes an impact on plant life activities, resistance of plants to adversities

Types of stress

- Biotic stress

pathogen stress

- Abiotic stress

chilling stress

freezing stress

heat stress

wet stress

flood stress

drought stress

salt stress

temperature stress

water stress

Black mangrove / Khalsi *(Aegiceras corniculatum)*

Salt gland & salt crystal on leaf of Black mangrove

Stress avoidance

In the whole growth process does not meet with the face of adversity

Stress tolerance

Plant has a capacity of environmental stress defense, but a variety of physiological processes remain normal

Major reasons

Soil degradation, land resources shortage and salt-alkalization

Distribution

- land surface: 13.2×10^9 hectare
- arable lands: 7×10^9 hectare
- cultivated lands: 1.5×10^9 hectare
- saline soil: 0.34×10^9 hectare (23%)
- alkaline soil: 0.56×10^9 hectare (37%)

Salinization of soil

- main cation: Na^+, Ca^{2+}, Mg^{2+}, K^+
  main anion: Cl^-, SO_4^{2-}, HCO_3^-, CO_3^{2-}, NO_3^-
  main salt $NaCl$, Na_2SO_4, Na_2CO_3, $NaHCO_3$
- saline soil: $NaCl$, Na_2SO_4 in soil
  alkaline soil: Na_2CO_3, $NaHCO_3$ in soil
  saline-alkaline soil

Address to growing salt problem

- halophytes have been studied as the principal species for exploiting and recovering saline-alkalinized soil.
- An increasing number of reports on distribution, exploitation, and physiological mechanisms of saline resistance of halophytes have been published.

Salt tolerance and salinity effects on plants; a review
AK Parida, AB Das - Ecotoxicology and environmental safety, 2005 – Elsevier
Cited by ~5000 related articles

ELSEVIER

Available online at www.sciencedirect.com
SCIENCE DIRECT®

Ecotoxicology and Environmental Safety 60 (2005) 324–349

Ecotoxicology and Environmental Safety
www.elsevier.com/locate/ecoenv

Salt tolerance and salinity effects on plants: a review

Asish Kumar Parida[a], Anath Bandhu Das[a,b,*]

[a]*National Institute for Plant Biodiversity Conservation and Research, Nayapalli, Bhubaneswar 751015, Orissa, India*
[b]*Regional Plant Resource Centre, Nayapalli, Bhubaneswar 751015, Orissa, India*

Received 18 September 2003; received in revised form 8 March 2004; accepted 8 June 2004
Available online 7 August 2004

Abstract

Plants exposed to salt stress undergo changes in their environment. The ability of plants to tolerate salt is determined by multiple biochemical pathways that facilitate retention and/or acquisition of water, protect chloroplast functions, and maintain ion homeostasis. Essential pathways include those that lead to synthesis of osmotically active metabolites, specific proteins, and certain free radical scavenging enzymes that control ion and water flux and support scavenging of oxygen radicals or chaperones. The ability of plants to detoxify radicals under conditions of salt stress is probably the most critical requirement. Many salt-tolerant species accumulate methylated metabolites, which play crucial dual roles as osmoprotectants and as radical scavengers. Their synthesis is correlated with stress-induced enhancement of photorespiration. In this paper, plant responses to salinity stress are reviewed with emphasis on physiological, biochemical, and molecular mechanisms of salt tolerance. This review may help in interdisciplinary studies to assess the ecological significance of salt stress.

Keywords: Antioxidative enzymes; Compatible solutes; Ion homeostasis; Photosynthesis; Salt stress

Salt stress

- The main point is the effects of saline stresses on growth of mangroves seedlings
- salt stress
- neutral salt stress
- alkaline salt stress
- alkali-stress (A)
- salt-stress (S)

Mechanism disordered

Deleterious effects of salt stress result primarily from osmotic stress and ion toxicities.

Mechanism disordered

Under alkaline stress, the salinized soil contains HCO_3^- and CO_3^{2-}, in addition to osmotic stress and ion toxicities, plants also have to deal with stress of high pH.

Mechanisms of Plant Adaptation

- Osmotic regulation

- Ion regionalization

Osmotic regulation

reduce volume reduce water content

absorb the inorganic ions in vacuole

Na^{+}, K^{+},Ca^{2+},Mg^{2+},$Cl^{-}$$SO_4^{2-}$,NO_3^{-}

synthetic organics accumulate in the cytoplasm

Proline, soluble sugar, organic acid, betaine

Ion regionalization

Intracellular ion balance, a stable tissue pH is necessary for plants to maintain normal metabolism.

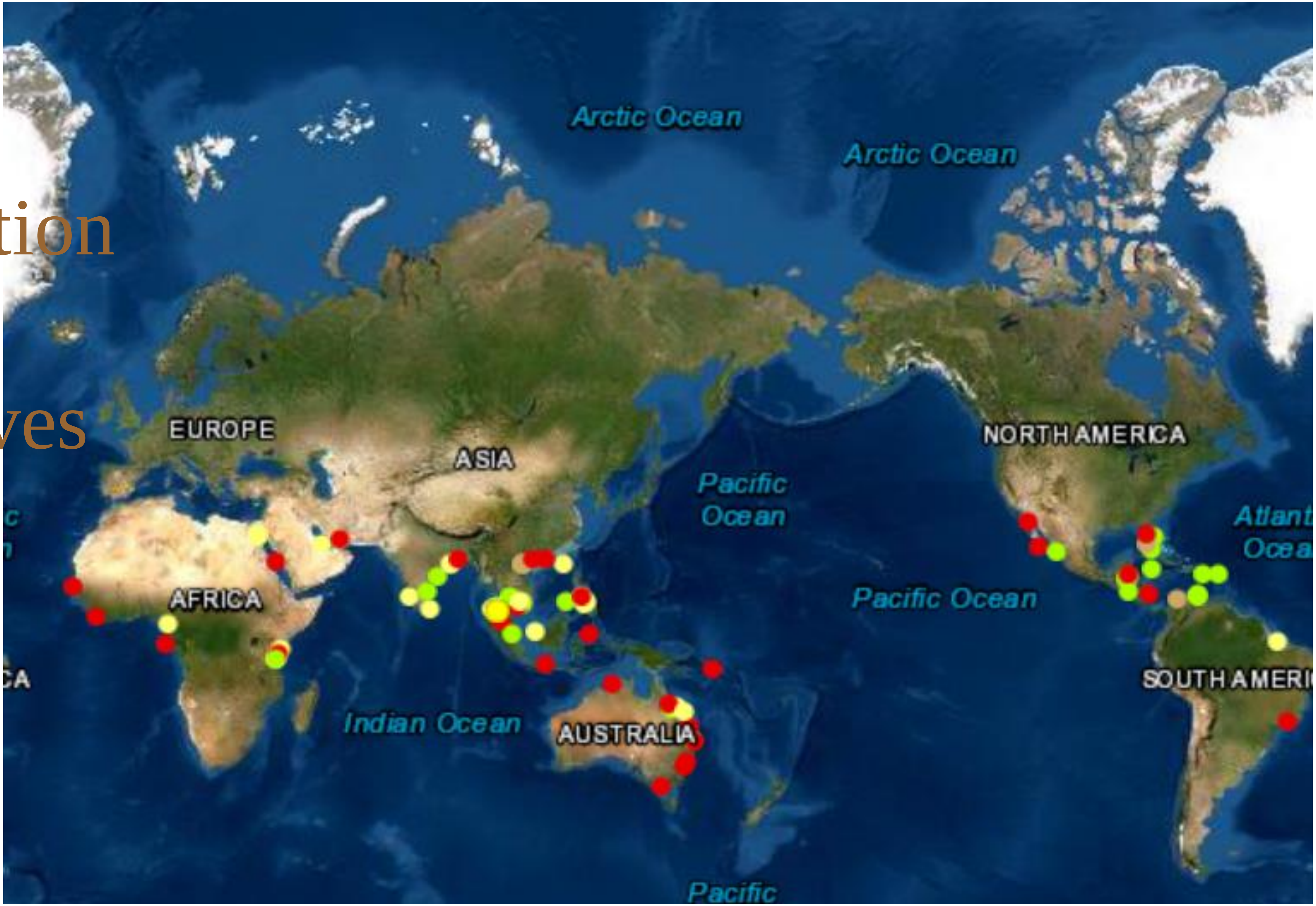
In a living plant, as long as the plant can adapt to the environment, the pH value in its tissue should be stable regardless of how the environmental pH value changes.

High-salt environments can break the ion homeostasis of plant cells, destroy the ion balance.

Under salt stress, it is necessary to osmotically adjust and re-establish the ion balance in cells for plants living.

Plants regulate the intracellular pH to keep ion balance by ion regionalization

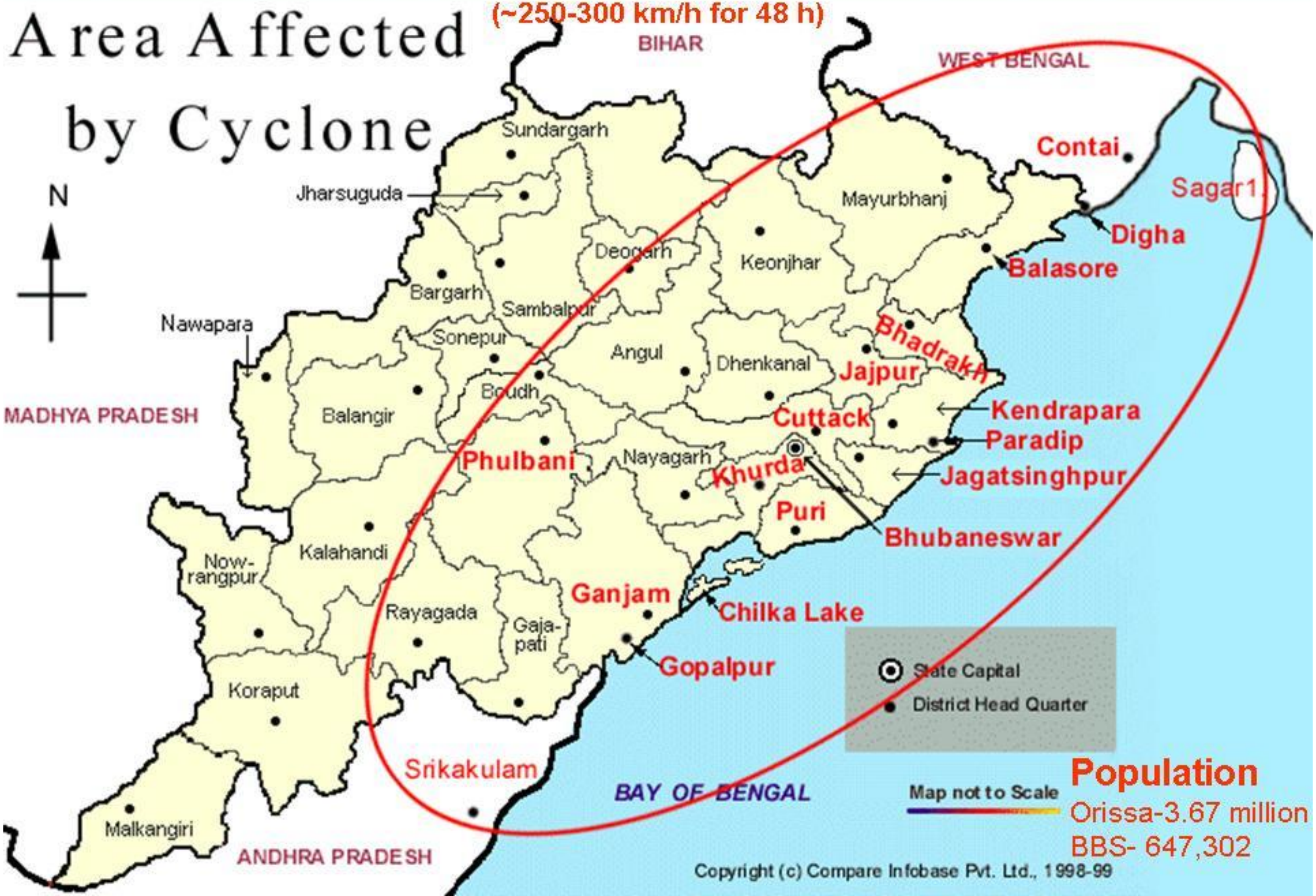
World Distribution Of Mangroves



- Deforestation/conservation/ restored vs degraded mangroves
- Nursery/fishing/ aquaculture
- Carbon sequestering/ climate change
- Strom protection/erosion mitigation/Coastal development

World Mangrove distribution

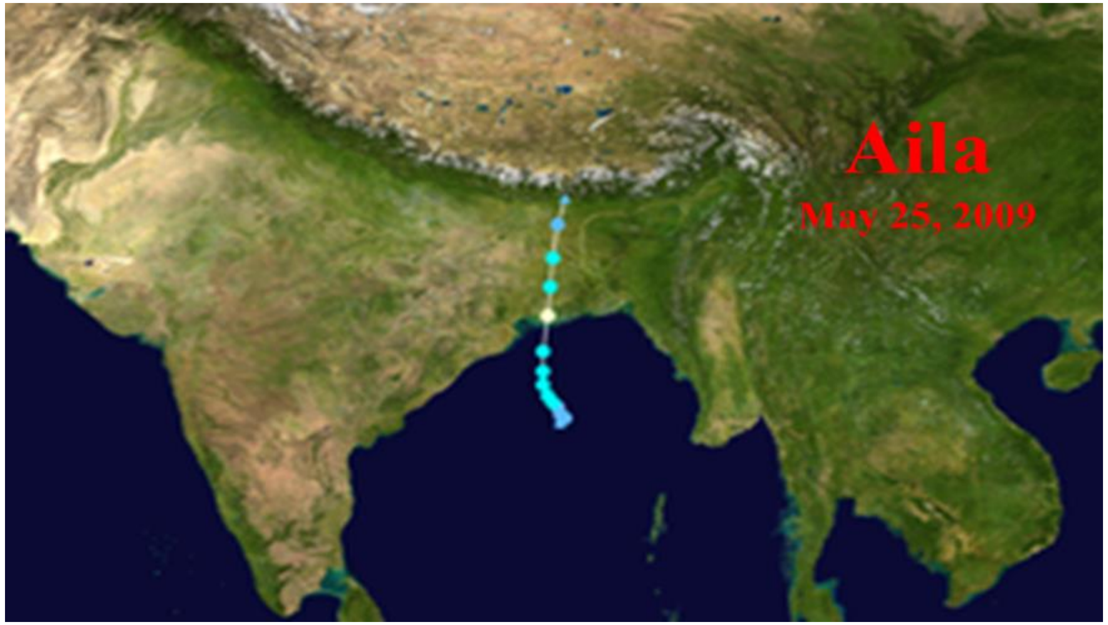
Cyclone affected coastal belt of Orissa in 1999

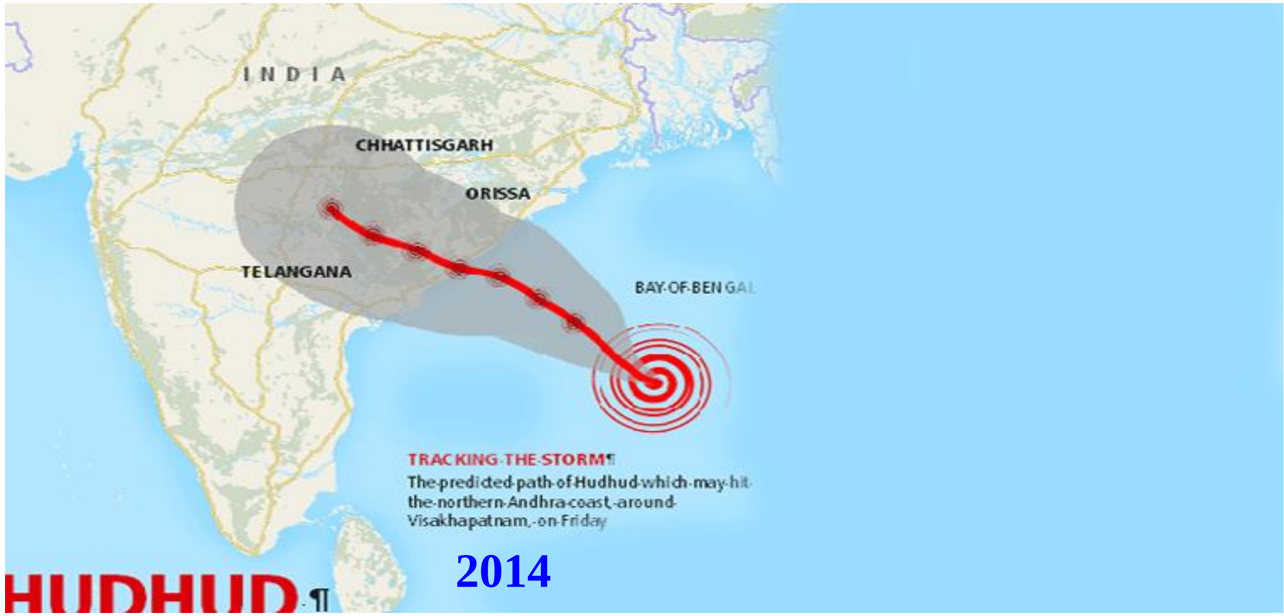


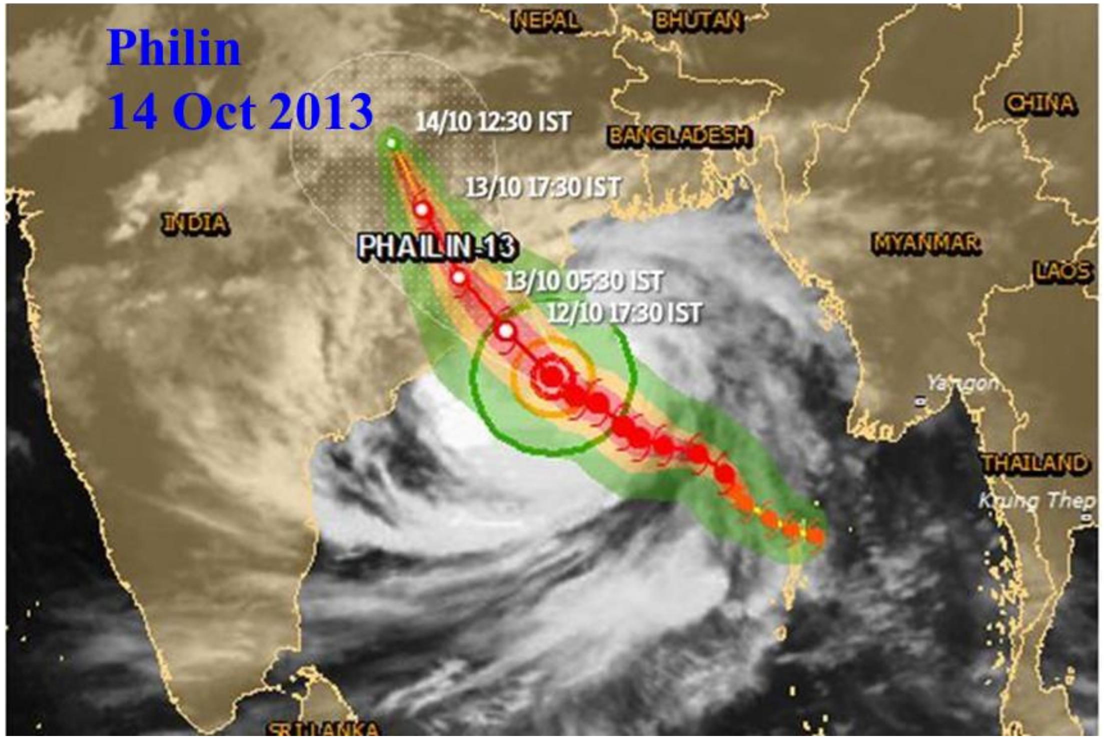
Population

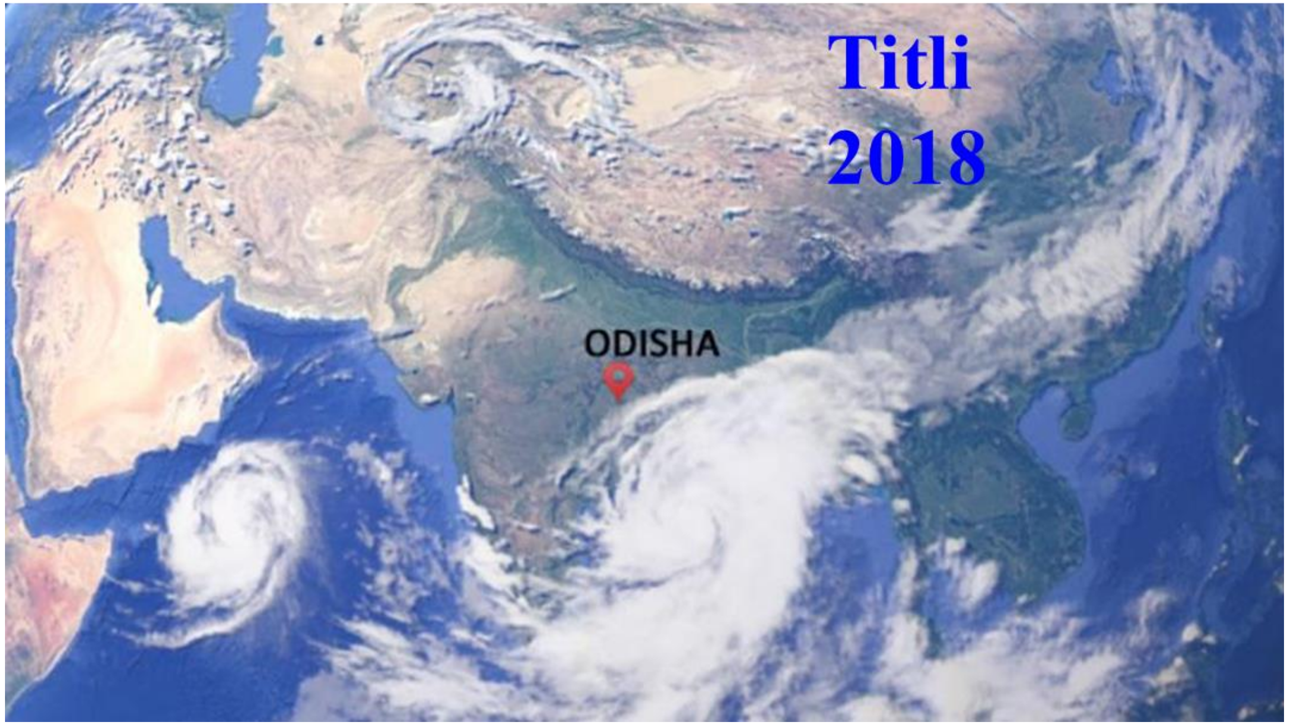
Orissa-3.67 million

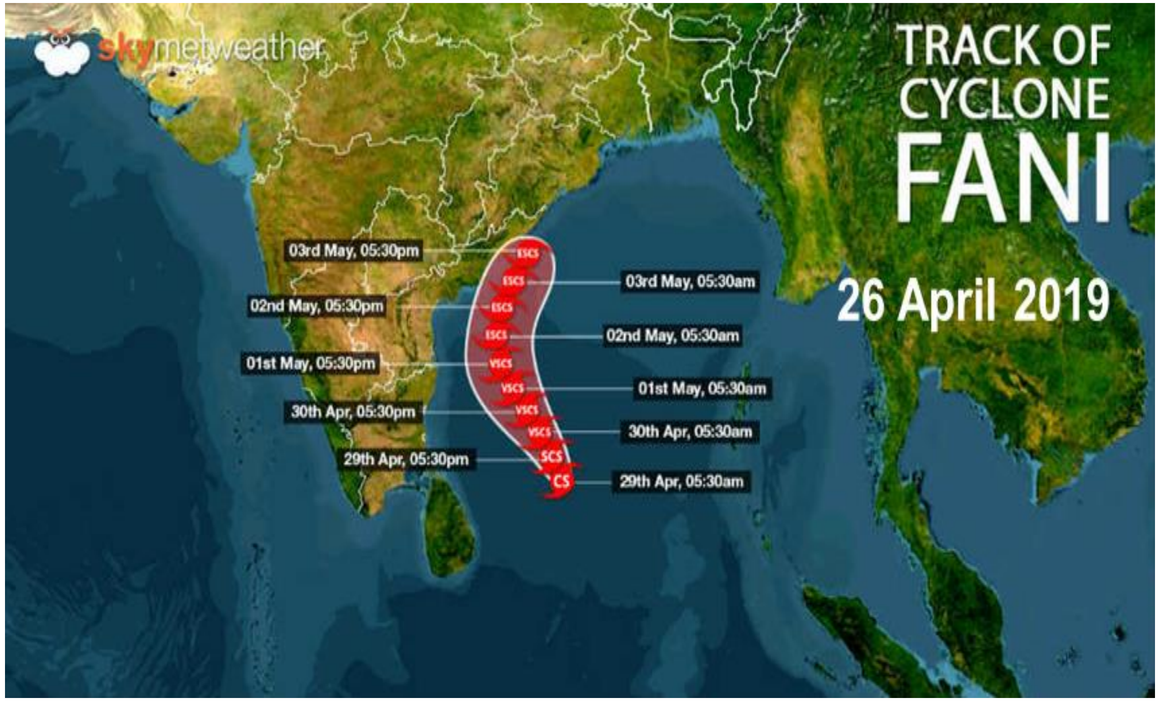
BBS- 647,302

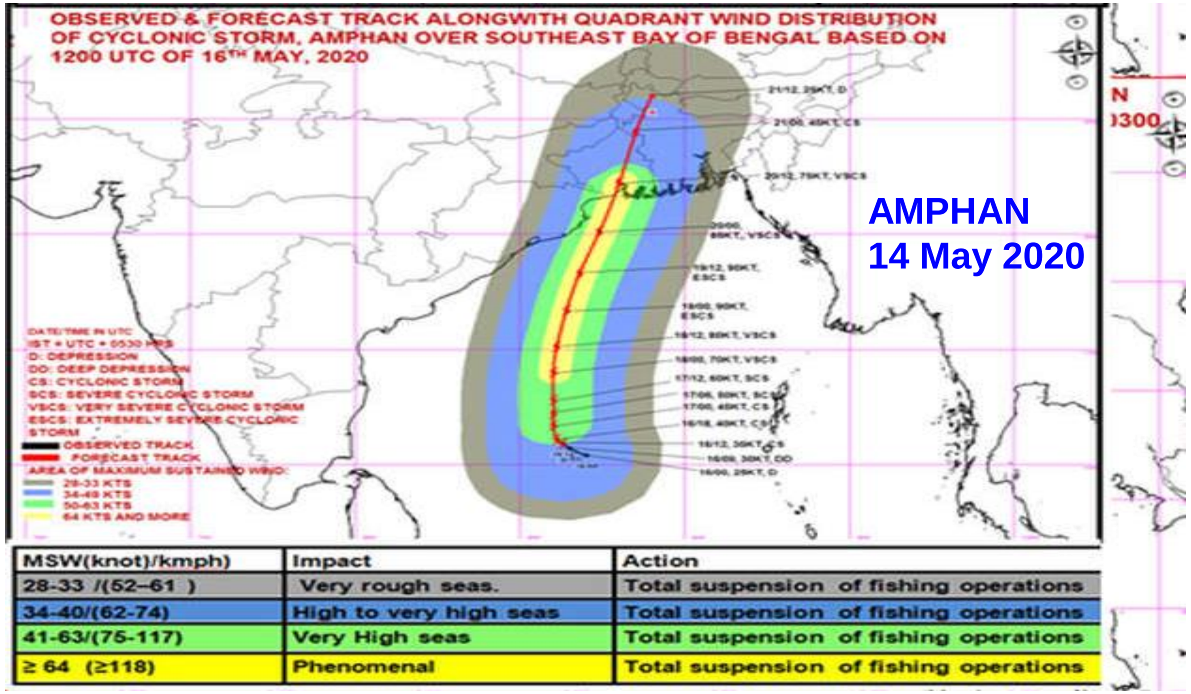

Aila
May 25, 2009

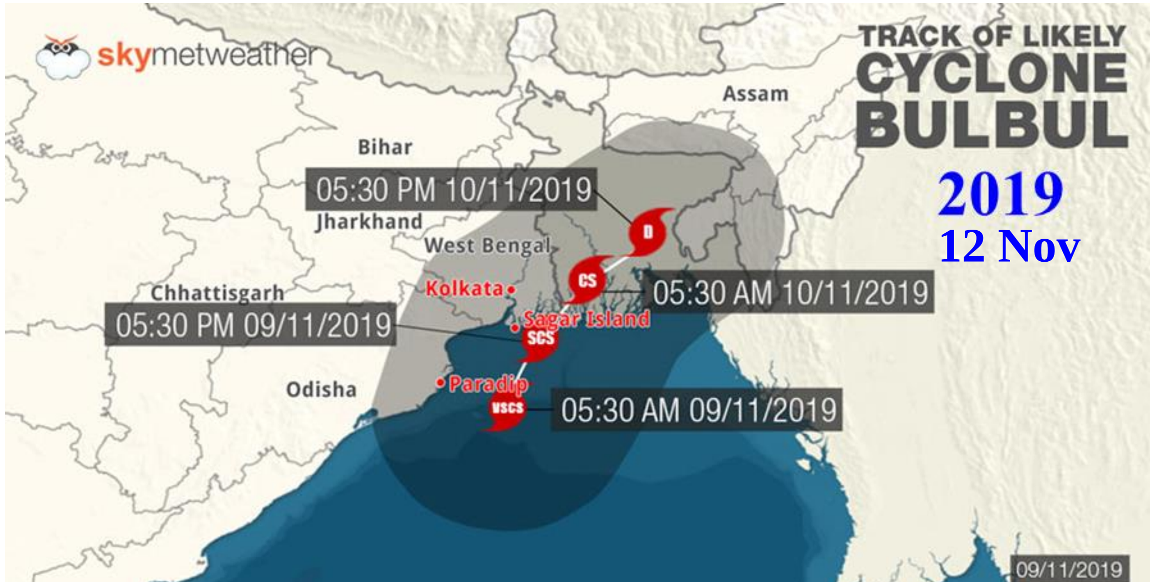

INDIA
CHHATTISGARH
ORISSA
TELANGANA
BAY OF BENGAL
TRACKING THE STORM¶
The predicted path of Hudhud which may hit the northern Andhra coast around Visakhapatnam, on Friday
HUDHUD ¶
2014

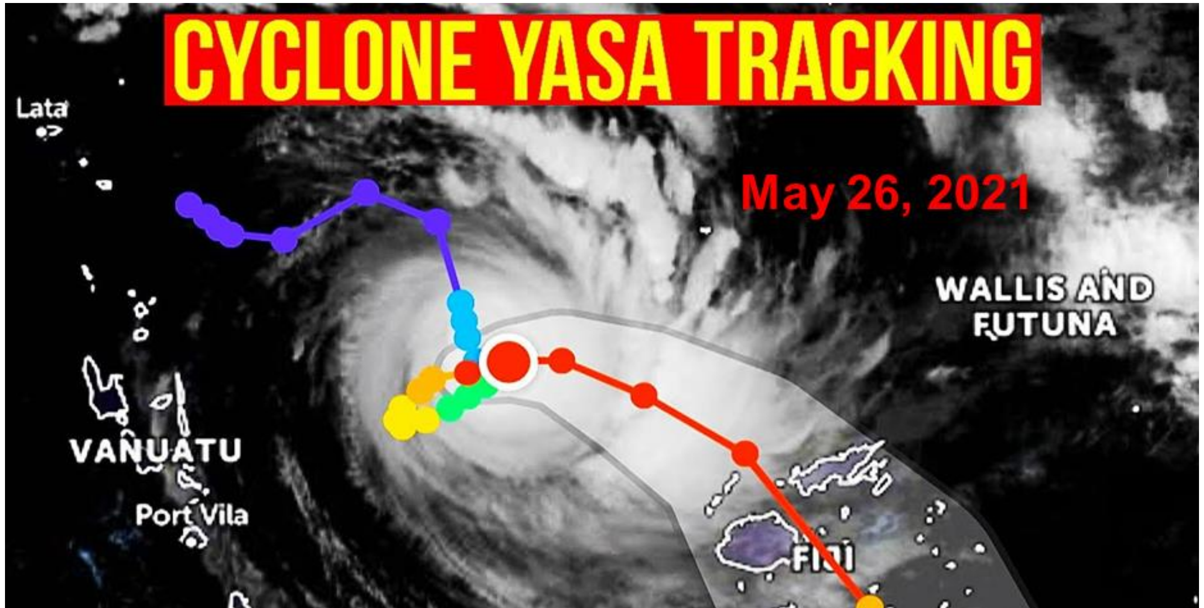

Philin
14 Oct 2013
NEPAL
BHUTAN
CHINA
14/10 12:30 IST
BANGLADESH
13/10 17:30 IST
INDIA
PHAILIN-13
MYANMAR
LAOS
13/10 05:30 IST
12/10 17:30 IST
Yangon
THAILAND
Krung Thep
SRI LANKA


Titli
2018
ODISHA


skymetweather
TRACK OF CYCLONE FANI
26 April 2019
03rd May, 05:30pm
02nd May, 05:30pm
01st May, 05:30pm
30th Apr, 05:30pm
29th Apr, 05:30pm
03rd May, 05:30am
02nd May, 05:30am
01st May, 05:30am
30th Apr, 05:30am
29th Apr, 05:30am


OBSERVED & FORECAST TRACK ALONGWITH QUADRANT WIND DISTRIBUTION OF CYCLONIC STORM, AMPHAN OVER SOUTHEAST BAY OF BENGAL BASED ON 1200 UTC OF 16TH MAY, 2020
AMPHAN
14 May 2020
MSW(knot)/kmph | Impact | Action
28-33 /(52–61) | Very rough seas. | Total suspension of fishing operations
34-40/(62-74) | High to very high seas | Total suspension of fishing operations
41-63/(75-117) | Very High seas | Total suspension of fishing operations
≥ 64 (≥118) | Phenomenal | Total suspension of fishing operations


skymetweather
TRACK OF LIKELY CYCLONE BULBUL
2019
12 Nov
Assam
Bihar
Jharkhand
West Bengal
Chhattisgarh
Odisha
Kolkata
Sagar Island
Paradip
05:30 PM 10/11/2019
05:30 AM 10/11/2019
05:30 PM 09/11/2019
05:30 AM 09/11/2019
09/11/2019

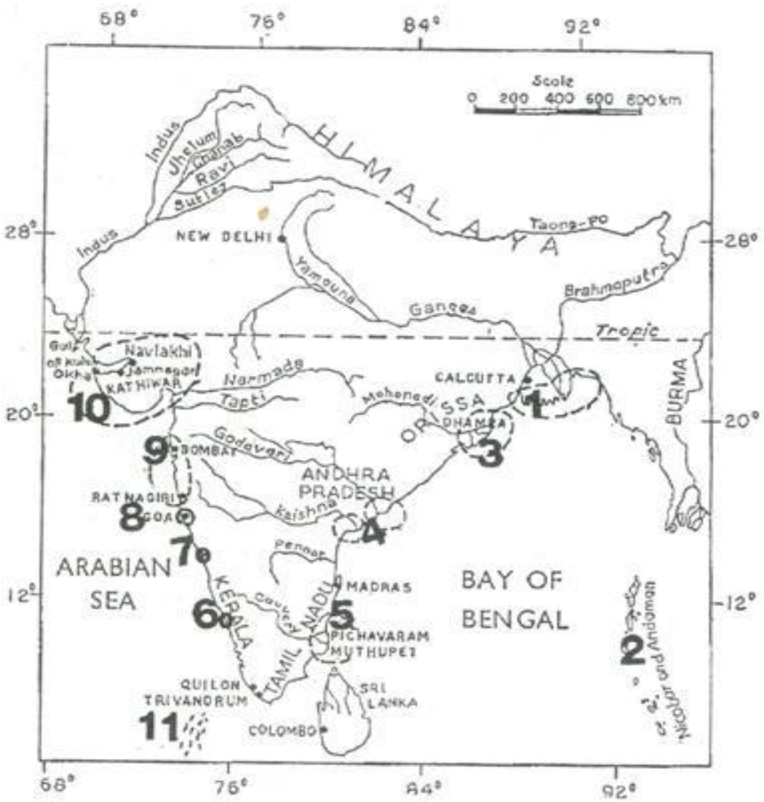

CYCLONE YASA TRACKING
May 26, 2021
Lata
WALLIS AND FUTUNA
VANUATU
Port Vila
FIJI

Bhitarkanika Mangroves



Indian distribution

Mangrove of Indian Sub-Continent



1. West Bengal Ganga Delta	4267 kms
2. Andaman & Nicobar Islands	1152 kms
3. Orissa coast, Bhitarkanika	120 kms
4. Andhra Pradesh coast	184 kms
5. Tamilnadu coast	26 kms
6. Kerala coast	NG
7. Kamataka coast	60 kms
8. Goa coast	20 kms
9. Maharastra coast	330 kms
10. Gujrat coast	260 kms
11. Mangroves of Lashadweep & Minicoy	Ng

Mangroves in low tide condition

Mangrove Conservation for Sustainable Use

- Mangrove ecosystems are under threat from a changing set of pressures.
- Primary threats to mangroves have come from conversion for aquaculture or agricultural use, and cutting for timber.
- While these remain significant, new threats are emerging, including pollution, diversion of upstream water sources, offshore mining and land reclamation for development.

Mangrove Conservation for Sustainable Use

- Mangroves worldwide face multiple threats and are disappearing despite the essential services they provide supporting the livelihoods of over 120 million people across the globe.
- Need to develop a comprehensive study detailing the legal and institutional frameworks affecting mangroves, and their impact on stakeholders' behaviour and the natural environment.

Area distribution of mangroves in India (thousand ha)

Mangrove distribution		
State/Union territory	Government of India, 1987	Government of India, 1997
West Bengal (Sundarbans)	420	212.3
Andaman and Nicobar Islands	119	96.6
Maharashtra	33	12.4
Gujarat	26	99.1
Andhra Pradesh	20	38.3
Tamil Nadu	15	2.1
Orissa	15	21.1
Karnataka	6	0.3
Goa	20	0.5
Kerala	Sparse	Nil
Total	674	482.7

Mangrove Degradation in India

- In India, mangroves occur on the West Coast, on the East Coast and on Andaman and Nicobar Islands, but in many places they are highly degraded.
- According to the Government of India (1987), India lost 40 percent of its mangrove area in the last century.
- The National Remote Sensing Agency (NRSA) recorded a decline of 7 000 ha of mangroves in India within the six-year period from 1975 to 1981.
- In Andaman and Nicobar Islands about 22 400 ha of mangroves were lost between 1987 and 1997.

Need for Mangrove Conservation and management

- Increased pressure on mangrove ecosystems in many countries, with the growing demand for timber, fuelwood, fodder and other non-wood forest products (NWFPs) due to increasing human population in coastal areas.
- Conservation of mangroves for environmental benefits, together with a sustainable supply of various forest products are needed to meet the day-to-day requirements of local people.
- Management will open new avenues for self-employment like ecotourism, fishing, beekeeping and mangrove forest products related cottage industries to improve the socio-economic conditions of the local communities.

Management of Mangroves in India

- First mangroves in the world to be put under scientific management Plan in Sundarbans mangroves implemented in 1892.

- Amendment to the Indian Constitution in 1976, states that it shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife.

- Government of India set up the National Mangrove Committee in the Ministry of Environment and Forests in 1976 to advise the government about mangrove conservation and development.

Management of Mangroves in India Conti..

- The government subsequently introduced a scheme for mangrove conservation and protection, consisting of:
  - identification of selected mangrove areas for conservation;
  - preparation of a management plan;
  - promotion of research;
  - adoption of a multidisciplinary approach involving state governments, universities, research institutions and local organizations.

Management of Mangroves in India Conti..

- In 1979, the National Mangrove Committee recommended areas for research and development and for management of the mangroves, which included the following:

- nationwide mapping of the mangrove areas, preferably by remote sensing techniques coupled with land surveys, and time series to assess the rate of degradation of the ecosystems;
- quantitative surveys of area, climatic regime, rate of growth of forest trees and seasonal variations of environmental parameters;

Management of Mangroves in India Conti..

- assessment of suitable sites for reserve forests;
- conservation programmes;
- afforestation of degraded mangrove areas;
- study of management methods, the ecology of mangroves, their flora and fauna, their microbiology and the biochemistry of organic matter and sediments.

National Mangrove Committee recommended, identified 15 mangrove areas in India for conservation.

Management of Mangroves in India Conti..

The Government of India has provided financial assistance to states and Union territories for the preparation and implementation of Management Action Plans for the conservation and development of these mangrove ecosystems.

- The plans broadly cover survey and demarcation, natural regeneration in selected areas, afforestation, protection measures, fencing and awareness programmes.
- The government also supports research by academic institutions for development of mangrove ecosystems on a sound ecological basis.
- The National Forest Policy, 1988 lists effective conservation and management of natural forest ecosystems (including the mangrove ecosystem) as a priority area for forestry research.

Identified Mangroves Sites in India

Legislative Framework

- The Indian Forest Act, 1927 and the Wildlife (Protection) Act, 1972 provide protection to flora and fauna.
- Although they do not specifically mention mangroves, these acts can also apply to the conservation of the flora and fauna of mangrove ecosystems.
- Since 1927, the Indian Forest Act has been applied to the mangrove forests of the Sundarbans, which have been declared as a reserved area.
- The Forest Conservation Act, 1980 states that no forest area shall be diverted for any non-forestry purpose without prior approval of the Government of India.

Legislative Framework Conti..

- The Environment (Protection) Act, 1986 has had a crucial role in the conservation and management of mangrove ecosystems.

- It declares a Coastal Regulation Zone in which industrial and other activities such as discharge of untreated water and effluents, dumping of waste, land reclamation and bunding are restricted in order to protect the coastal environment.

- Enforcement of the legislative mandates is a prime need.

Mangrove Conservation & Management Issues

- Most of the challenges to mangrove forests are natural hazards and destructive human activities. However, the gravity of the problems varies from area to area.
- Cyclones, typhoons and strong wave action.
- Browsing and trampling by wildlife (e.g. deer) and livestock (goats, buffaloes and cows), which are often left to graze freely, especially in areas close to human habitation

Mangrove Conservation & Management Issues

- Infestation by barnacles which attach to young seedlings, interfering with respiration and photosynthesis and delaying seedling growth.
- Damage by oysters and crabs to the young leaves and plumules of *Rhizophora* and *Ceriops* plants.
- Weeds like *Acrostichum aureum* and *Acanthus* species, which often occupy deforested mangrove areas.
- Drying and mortality of mangrove trees *Bruguiera*, *Avicennia* due to high salinity.

Problems Caused by Humans Activities

Indiscriminate tree felling and lopping, mainly for fuelwood, fodder and timber, especially in areas close to human habitation.

Indiscriminate conversion of mangroves on public lands for aquaculture (e.g. for prawn culture).

Effects of shrimp culture on mangroves in eastern India), agriculture, mining industrial purposes.

Problems Caused by Humans Activities

Encroachment mangrove forest lands and cultivation of paddy.

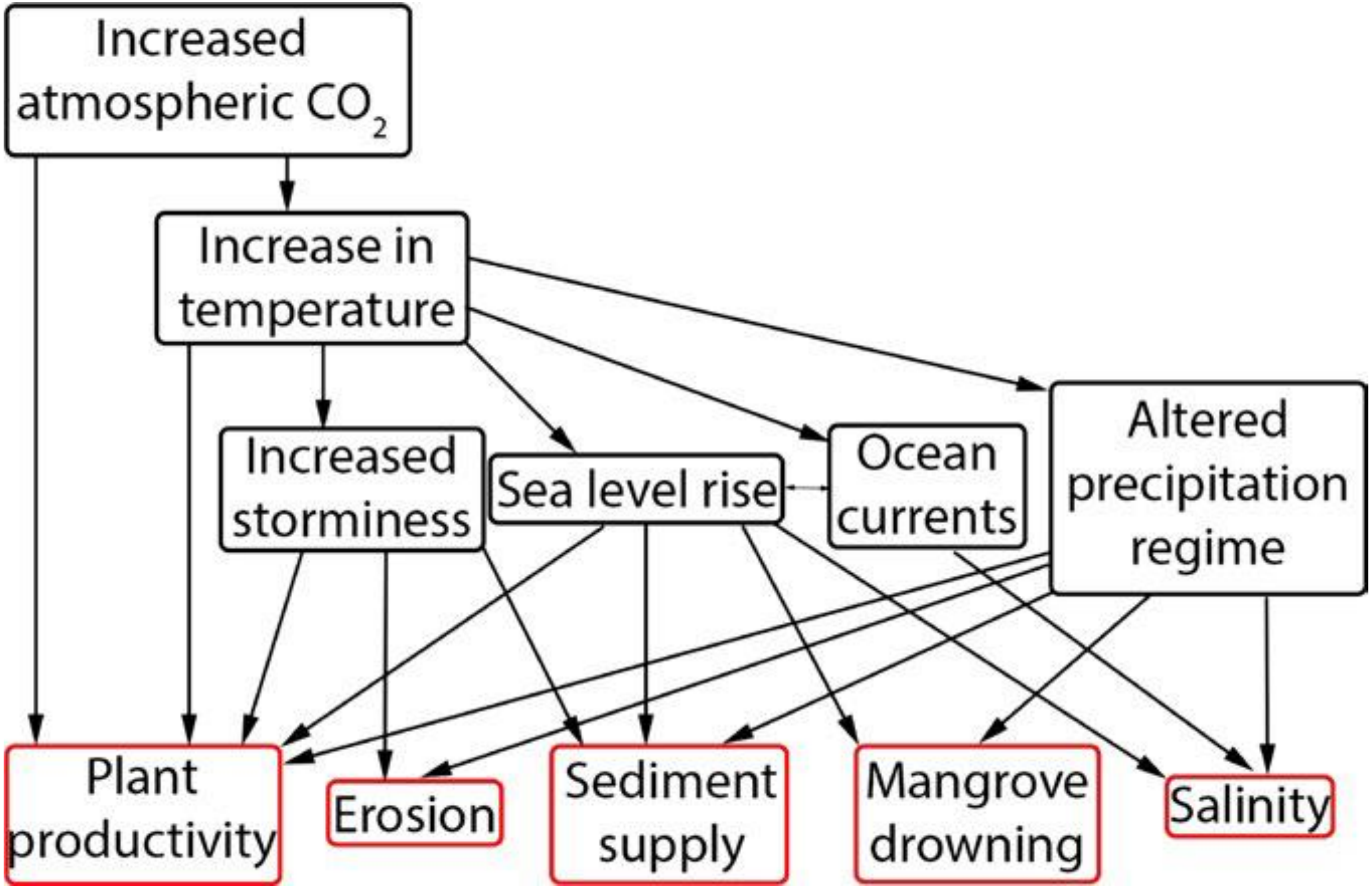
Lack of interest of private landowners in conserving and developing the mangroves.

Illegal collection of mangrove fruits (*Xylocarpus granatum*, *Xylocarpus moluecensis*, *Nypa fruticans* and *Heritiera littoralis*), which hinders their natural regeneration.

Discharge of industrial pollutants into creeks, rivers and estuaries.

The traditional use of dragnets in fishing, which often hampers regeneration of mangroves.

Influence of Climate Change on Mangroves

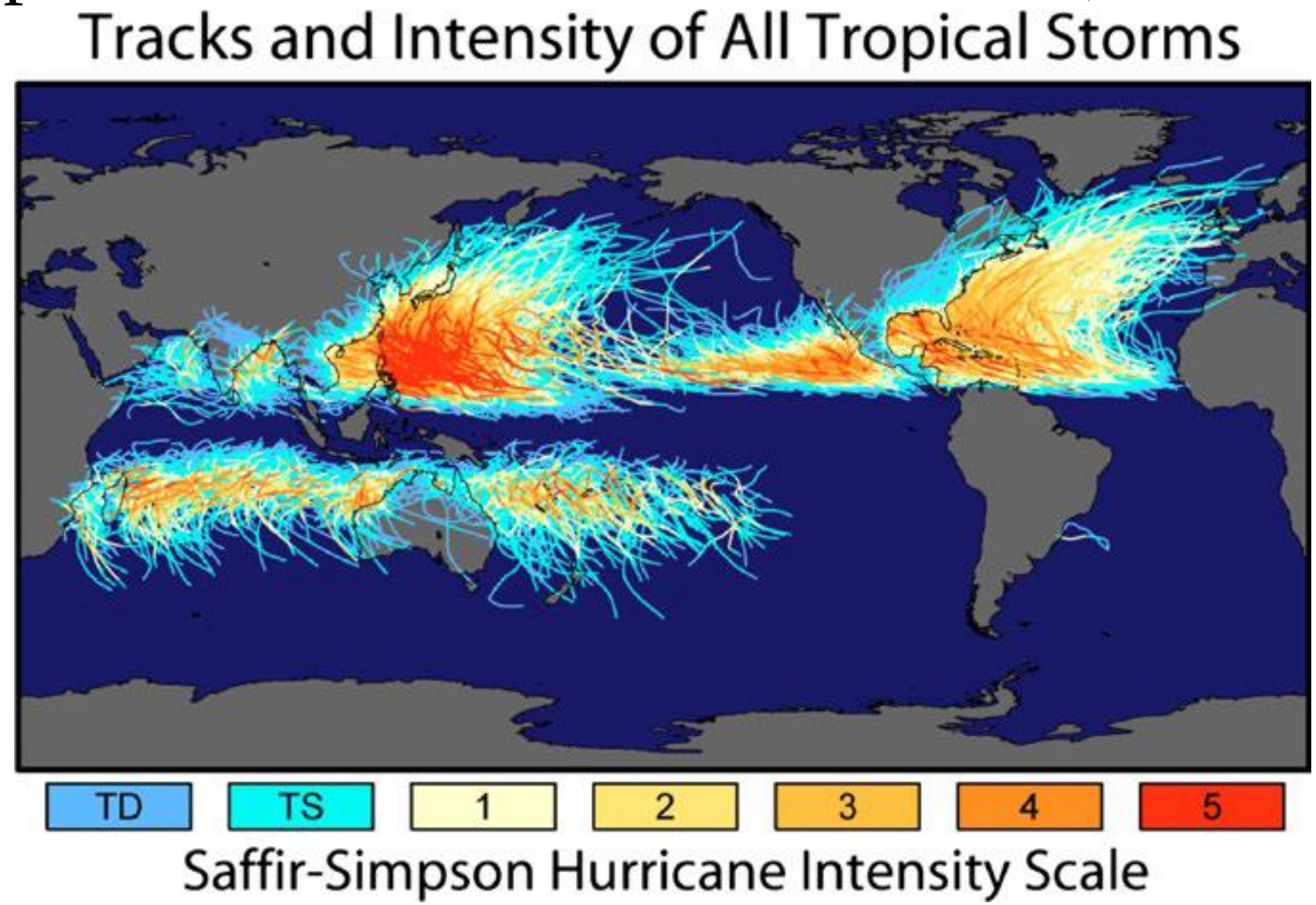


Sea Level Rise

- Sea level rise is a major potential climate change threat to mangrove ecosystems, because mangroves are sensitive to changes in inundation duration and frequency as well as salinity levels that exceed a species-specific physiological threshold of tolerance.
- Coastal flooding is expected to increase in the future because global sea levels have risen by 3.2 mm/yr over recent decades.
- By 2100, sea levels likely to rise by between 0.28 and 0.98 m.
- Sea level rise rates are highly variable, from **1.9 mm/yr in the Caribbean** to **7.5 mm/yr in parts of Indonesia** , and up to **9 mm/yr in the lower Mississippi River**.
- Thus, getting of organic matter in sea flore for mangroves is a big threat to mangroves.

Storminess

- The intensity of storms in a particular coastal zone is likely to be influenced by mangrove position in relation to storm track, storm characteristics.



Global distribution of tropical cyclone tracks between 1851 and 2006.
TD - Tropical Depression (≤17 m/s),
TS -Tropical Storm (18–32 m/s),
Category One (33–42 m/s),
Category Two (43–49 m/s),
Category Three (50–58 m/s),
Category Four (59–69 m/s),
Category Five (≥70 m/s).
Source: NASA (2006).

Temperature

- Global temperatures are predicted to increase by up to 4.8° C by 2081–2100 relative to 1986–2005 (IPCC,2013, RCP8.5).
- Temperature influences the ability of mangroves to assimilate CO_2 as a result of the limitations to biochemical reactions.
- Where temperatures exceed that of peak photosynthesis productivity decreases and when leaf temperatures exceed 38–40° C, photosynthesis ceases.
- High temperatures increase evaporation rates, which can result in salinity increases; the synergistic impacts of salinity and aridity can influence species diversity, size, and productivity of mangrove forests.

» Mangrove forests stabilize the coastline by reducing erosion caused by storm surges, currents, waves and tides.

» Mangroves protect water quality by removing nutrients and pollutants from stormwater runoff.

» Mangrove peat absorbs water during heavy rains and storm surge, reducing the chances of coastal flooding.

» Mangroves provide nursery habitat for many commercial fish and shellfish, and thus contribute to the local abundance of seafood.

» Mangrove systems provide shelter to a range of wildlife species including birds, deer and honey bees.

» Mangroves serve as nesting areas for coastal birds such as little blue herons, great egrets and brown pelicans.

Importance of Mangrove Biodiversity

- Mangrove trees and shrubs grow in coastal intertidal zones.
- Mangrove forests grow at tropical and subtropical latitudes because they cannot withstand freezing temperatures.
- Many mangrove forests can be recognized by prop roots that make the trees appear to be standing on stilts above the water.
- This tangle of roots allows the trees to handle the daily rise and fall of tides and slow the movement of tidal waters.
- Contribute $7.6 billion annually to the economy and create 109,000 jobs in Florida.

Salt Deposits on Soil

Lenticels /pneumatphores O_2 uptake

Rhizophora mucronata

To avoid salinity

Mangroves and global changes

- Rise in atmospheric CO_2,

  280ppm in 18th century increase to 355 ppm in 1991. The expected rise at ~0.5% or 1.5ppm per year

- Global warming

  Global mean temperature increases 0.3oC to 0.6°C since 19th century, year 2025 – expected ~1°C above and ~3°C above by 21st century

- Sea level rise

  due to thermal expansion of the world's ocens and melting of glaciers and major continental ice caps

  Year 2030 – expected rise 18 cm

  Year 2070 – expected rise 44 cm

  21st Century – expected rise 60 cm

(after Field 1995)

Mangrove flora diversity in Bhitarkanika & Mohanadi Delta

Major mangroves	20 species
Minor mangroves	10 species
Mangrove associates	64 species

Total family	44
Total genus	64
Total species	94

Chromosome analysis & DNA content

Species\ Family	Somatic chromosome number(2n)	Karyotype Formulae	4C DNA content	TF%
Chenopodiaceae				
13. *Suaeda nudiflora*	54	6A+2B+28C+18D	19.23	36.29
Combretaceae				
14. *Lumnitzera racemosa*	24	14C+10D	22.51	38.08
Euphorbiaceae				
15. *Excoecaria agallocha*	130	106C+22D	27.56	38.45
Fabaceae				
16. *Caesalpinia crista*	24	2A+12C+10D	15.76	37.96
17. *Cynometra ramiflora*	26	2A+18C+6D	8.97	38.71
18. *Dalbergia spinosa*	20	4B+12C+4D	10.82	38.93
19. *Derris heterophylla*	24	4A+14C+6D	16.96	39.33
20. *Derris indica*	22	4A+8C+10D	28.73	35.38
Meliaceae				
21. *Xylocarpus granatum*	42	4B+16C+22D	20.66	37.14
22. *X. mekongensis*	44	2A+30C+12D	22.52	38.38
Malvaceae				
23. *Hibiscus tiliaceous*	86	2A+74C+10D	18.72	43.73
24. *Thespesia populnea*	26	2A+2B+12C+10D	28.52	32.10
Myrtaceae				
25. *Syzygium cumini*	66	56C+10D	8.49	43.83
Myrsinaceae				
26. *Aegiceras corniculatum*	44	2B+36C+6D	17.61	40.46
Plumbaginaceae				
27. *Aegialitis rotendifolia*	34	2B+14C+18D	37.68	34.86

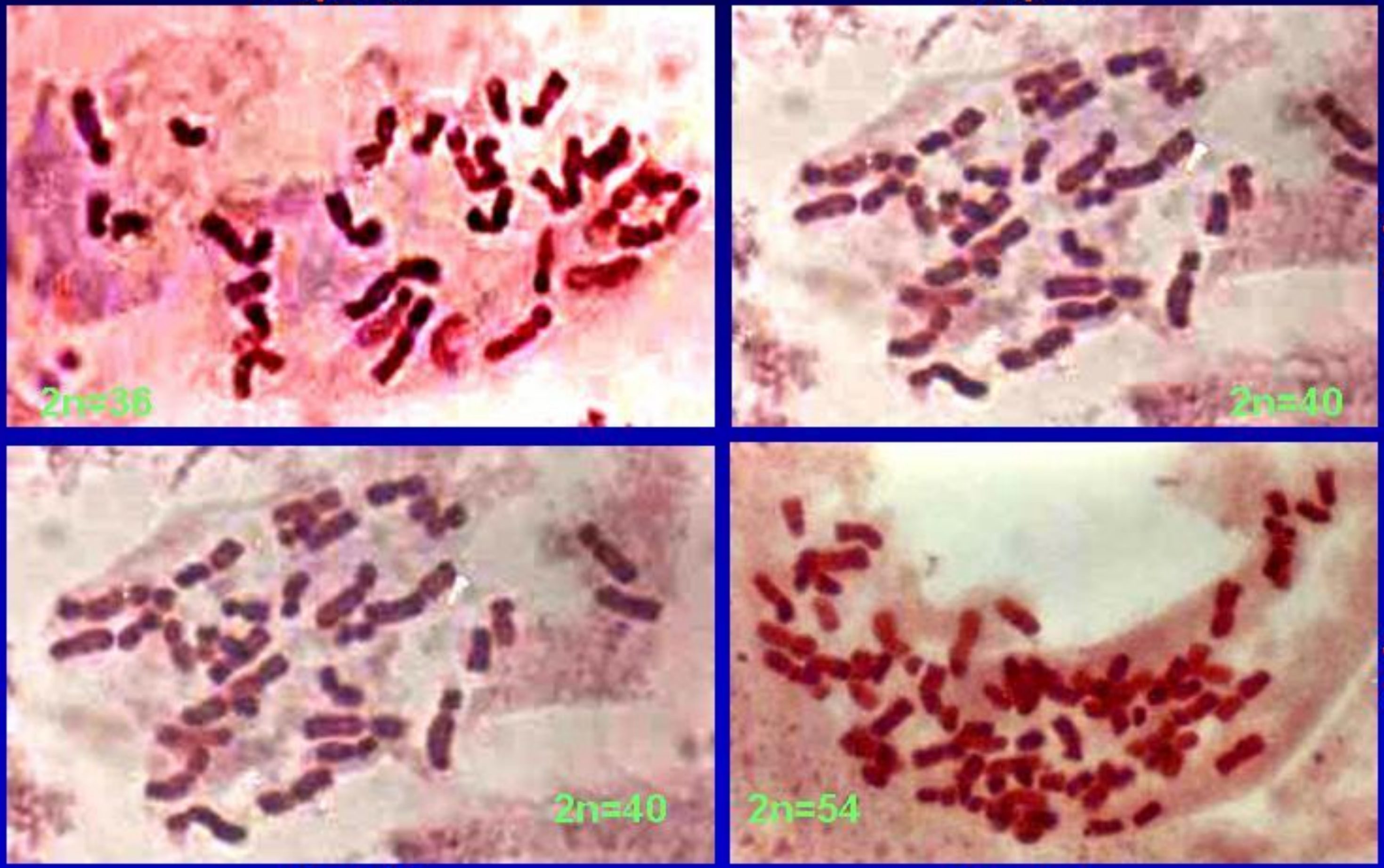
Chromosome analysis & DNA content

Species\ Family	Somatic chromosome number(2n)	Karyotype Formulae	4C DNA content	TF%
Rhizophoraceae				
28. *Kandelia candel*	38	4A+26C+8D	19.23	39.40
29. *Rhizophora apiculata*	36	28C+8D	3.25	40.19
30. *R. mucronata*	36	2A+22B+12D	15.21	35.00
31. *Bruguiera gymnorrhiza*	34	4A+20C+6D	8.97	34.96
32. *B. sexangula*	34	4A+26C+2D+2E	7.45	40.06
33. *B. parviflora*	34	6A+20C+8D	12.89	36.09
34. *B. cylindrica*	34	2A+4B+24C+4D	17.30	39.04
35. *C. decandra*	36	4A+28C+4D	11.12	41.25
36. *Ceriops tagal*	36	2A+24C+10D	18.14	42.45
Sterculiaceae				
37. *Heritiera fomes*	38	2A+2B+26C+8D	28.66	37.07
38. *H. macrophylla*	38	4A+20C+14D	25.17	34.15
39. *H. littoralis*	38	2A+28C+8D	22.26	39.80

Chromosomal marker in *different populations of* ***Suadea nudiflora***

Pop-I &II *Pop-III*

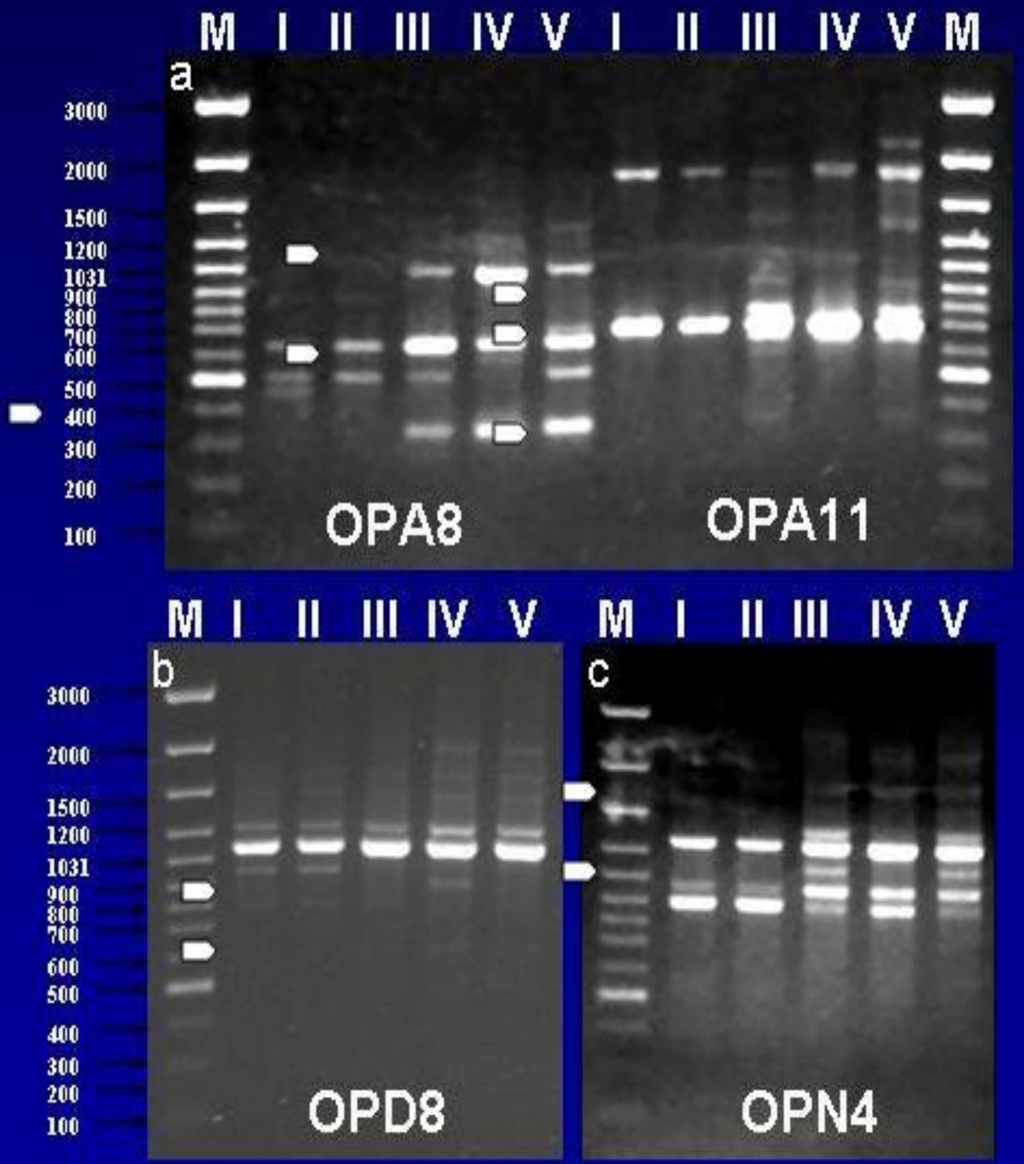
Salinity 3-16 ppm *Salinity 6-20 ppm*



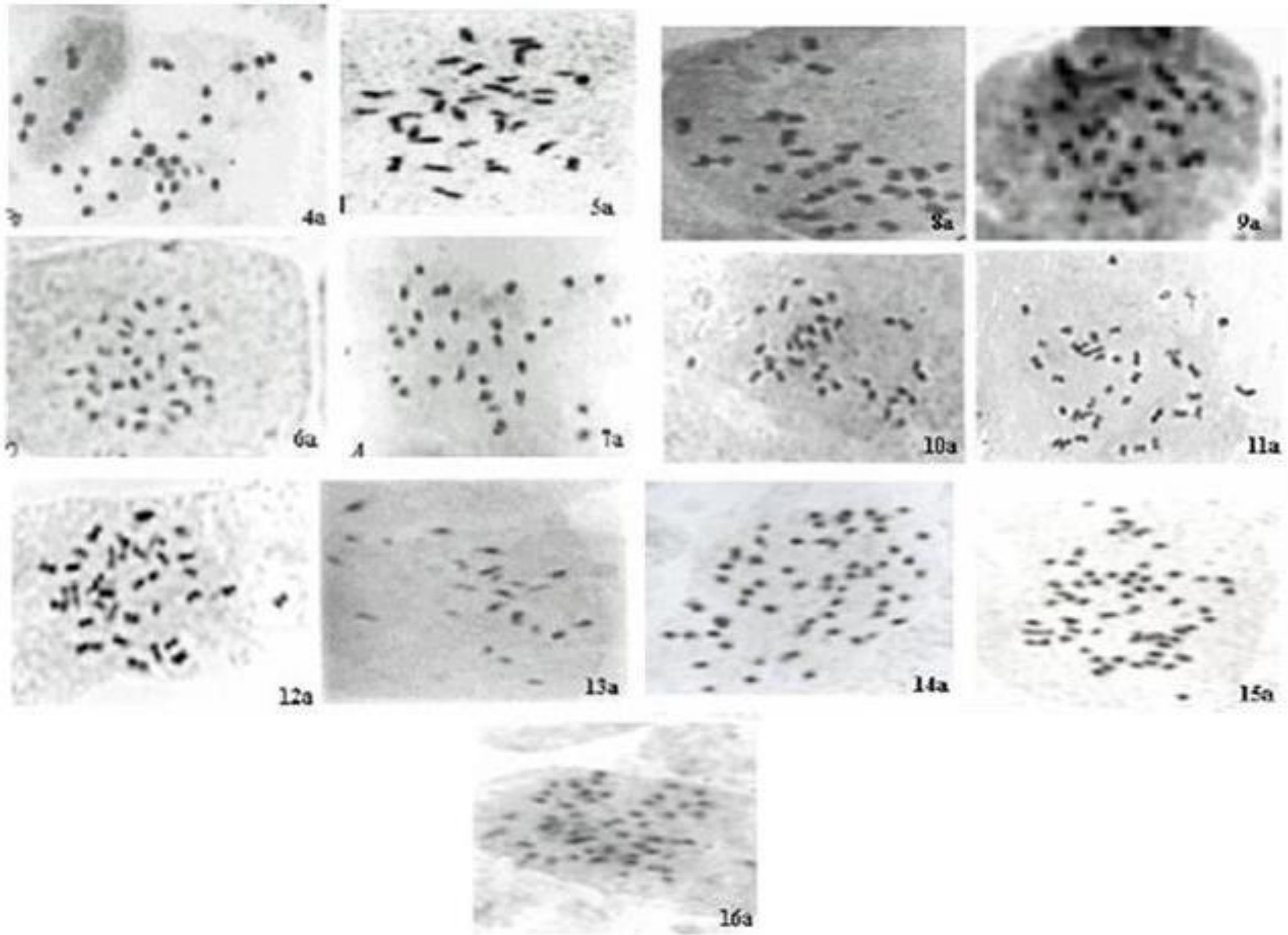
Salinity 6-20 ppm *Salinity 10-23 ppm*

Pop-V *Pop-IV*

Suadea nudiflora DNA marker in cytotypes



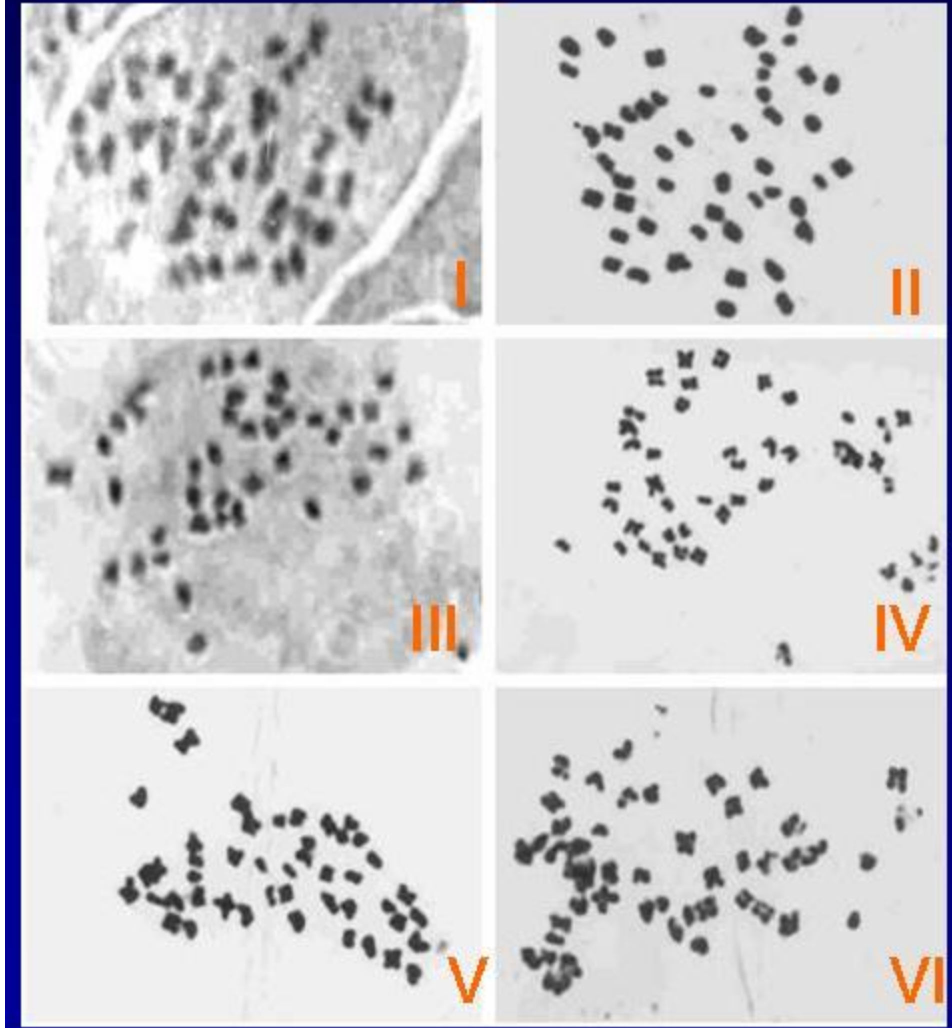
Somatic metaphase plates in different mangroves



Somatic chromosome plates of *B. parviflora (2n=34)*, *B. cylindrica (2n=34)* , *B. gymnorrhiza (2n=34)*, *B. sexangula (2n=34)*, C. *decandra (2n=36)*, *C. tagal (2n=36)*, *R. apiculata (2n=36)*, *R. mucronata (2n=36)*, *K. candel (2n=38)*, *L. racemosa (2n=24)*, *A. officinalis (2n=64)*, *A. alba (2n=62)*, *and A. marina (2n=66)* .

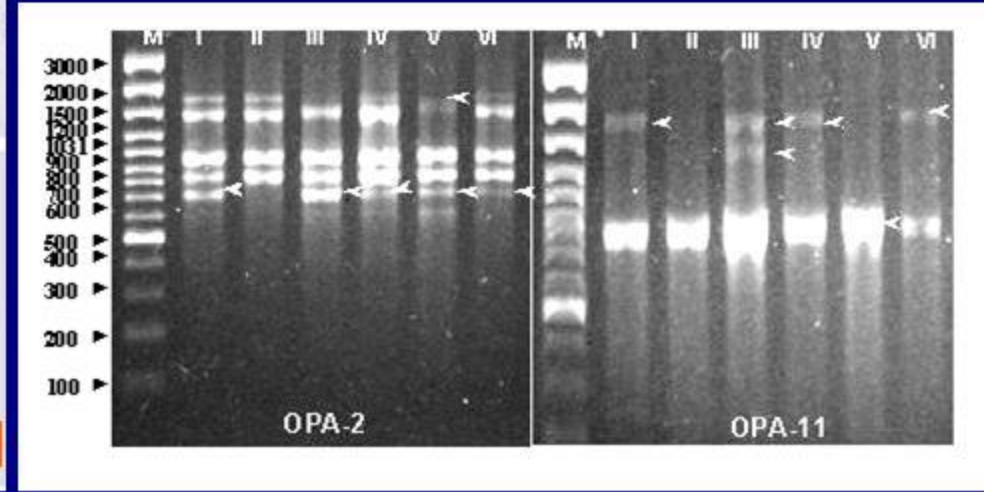
Chromosomal and DNA markers *in* *Acanthus ilicifolius*

Ecotypes

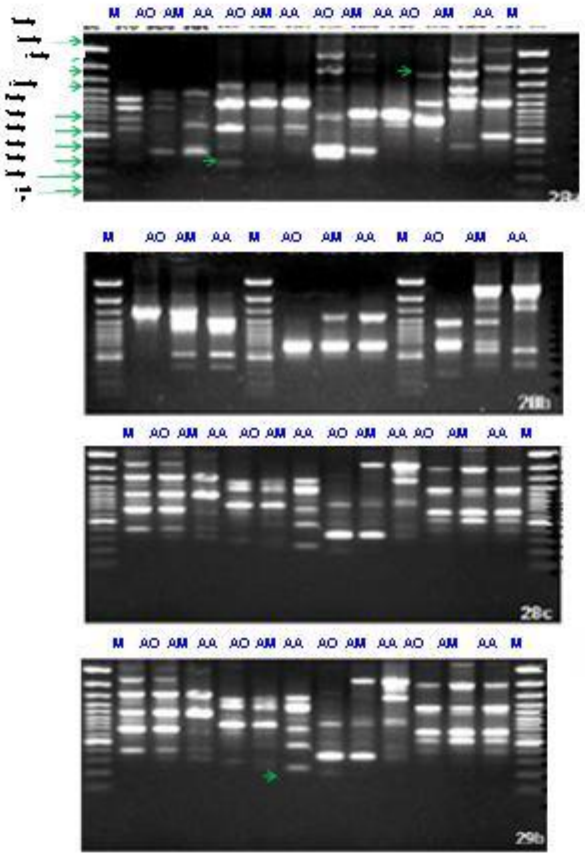


Karyogram

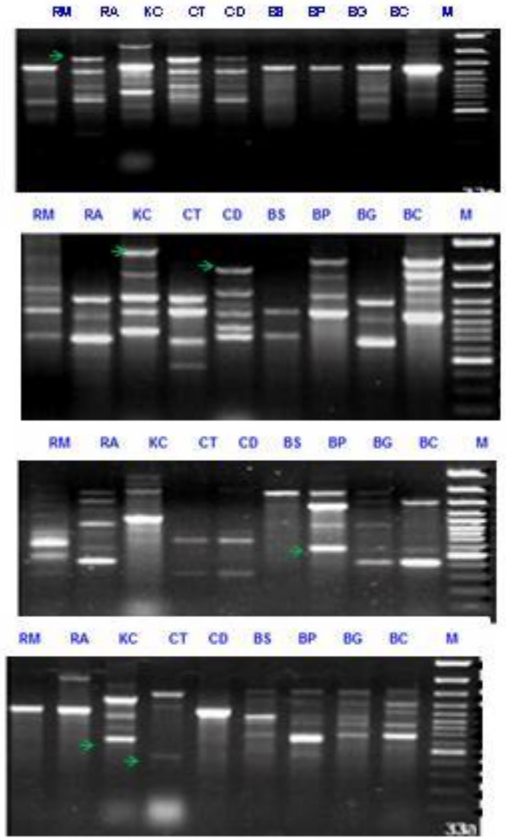
RAPD



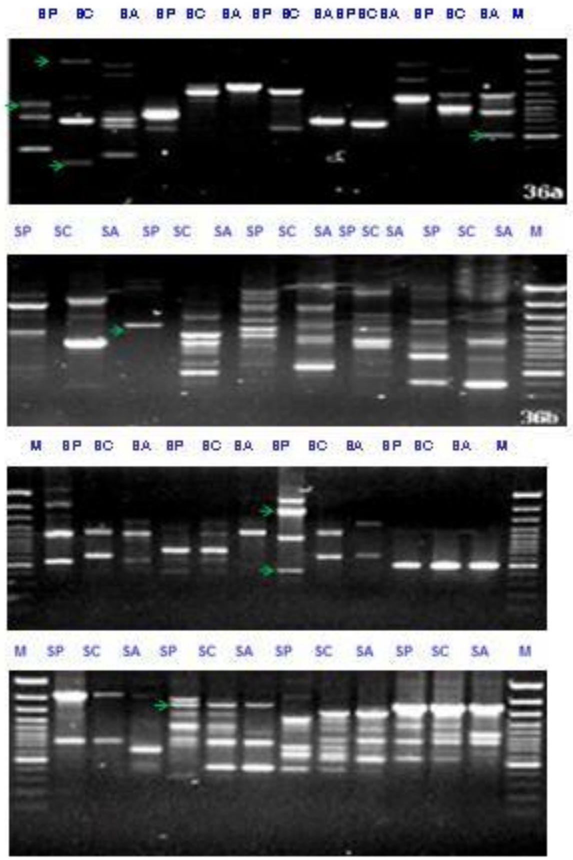
RAPD profile



RAPD profiles of Avicenniaceae by Primer-OPN14, OPN1, OPAF14, OPAF12, OPAF7, OPAF5, OPAF3, OPA7, OPA8, OPA11, OPA13



RAPD profiles of Rhizophoraceae by Primer-OPN5, OPA2, OPA12,OPA11.



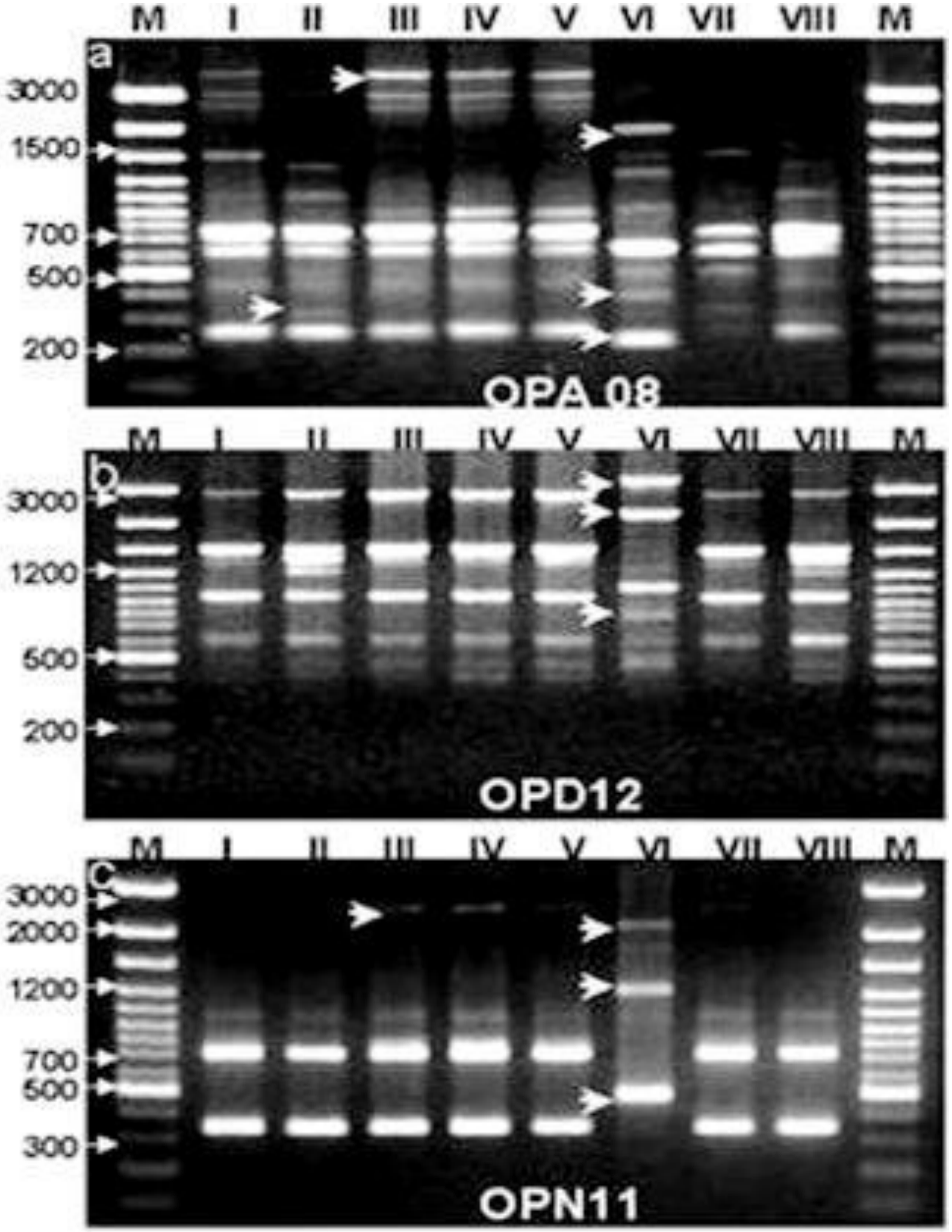
RAPD profiles of Sonneratiaceae by seven random decamer Primer-OPA1, OPA2, OPC1, OPAF2, OPAF3, OPN5, OPN10,OPN1,OPN3,OPN7,OPA8, OPA11,OPA13,OPA12, OPA7, OPA10,OPD3, OPN11.

Int. J. Tropical Biol. & Conservation (2007) 55 (2): 437-448

Genetica (2004) 122:217-226

Proc. 8th Orissa Bigyan Congress (2004)1:121-130

Xylocarpus granatum; Ecotypic variation



Identification of salt stress marker in mangroves

Hydroponic Culture

Bruguiera parviflora

Maximum tolerance

400 mM NaCl

Aegiceras corniculatum

Maximum tolerance
250 mM NaCl

Journal of Plant Physiology 161 (2004) 921–928

Available online at www.sciencedirect.com

SCIENCE DIRECT

JOURNAL OF PLANT PHYSIOLOGY

www.elsevier.de/jplph

Effects of NaCl stress on nitrogen and phosphorous metabolism in a true mangrove *Bruguiera parviflora* grown under hydroponic culture

Asish Kumar Parida[a], **Anath Bandhu Das**[a,b,*]

[a] *National Institute for Plant Biodiversity Conservation and Research, Nayapalli, Bhubaneswar, Orissa 751015, India*
[b] *Regional Plant Resource Centre, Nayapalli, Bhubaneswar, Orissa 751015, India*

Received 18 June 2003; accepted 15 November 2003

KEYWORDS
Acid phosphatase;
Bruguiera;
Hydroponic;
Mangrove;
Nitrate reductase;
Salt stress

Summary

The influence of varying levels of salinity (0, 100, 200 and 400 mM) on the activities of nitrate reductase (NR, E.C. 1.6.6.1), acid phosphatase (ACP, E.C. 3.1.3.2), and alkaline phosphatase (ALP, EC 3.1. 3.1) as well as on nitrate and phosphate uptake and total nitrogen levels in leaves of a true mangrove *Bruguiera parviflora* was investigated under hydroponic culture conditions. NR activity increased in 100 mM NaCl treated plants, whereas it decreased gradually in 200 and 400 mM treated plants, relative to the controls. Decreased activity of NR by NaCl stress was also accompanied

Trees (2004) 18:167–174
DOI 10.1007/s00468-003-0293-8

ORIGINAL ARTICLE

Asish Kumar Parida · A. B. Das · B. Mittra

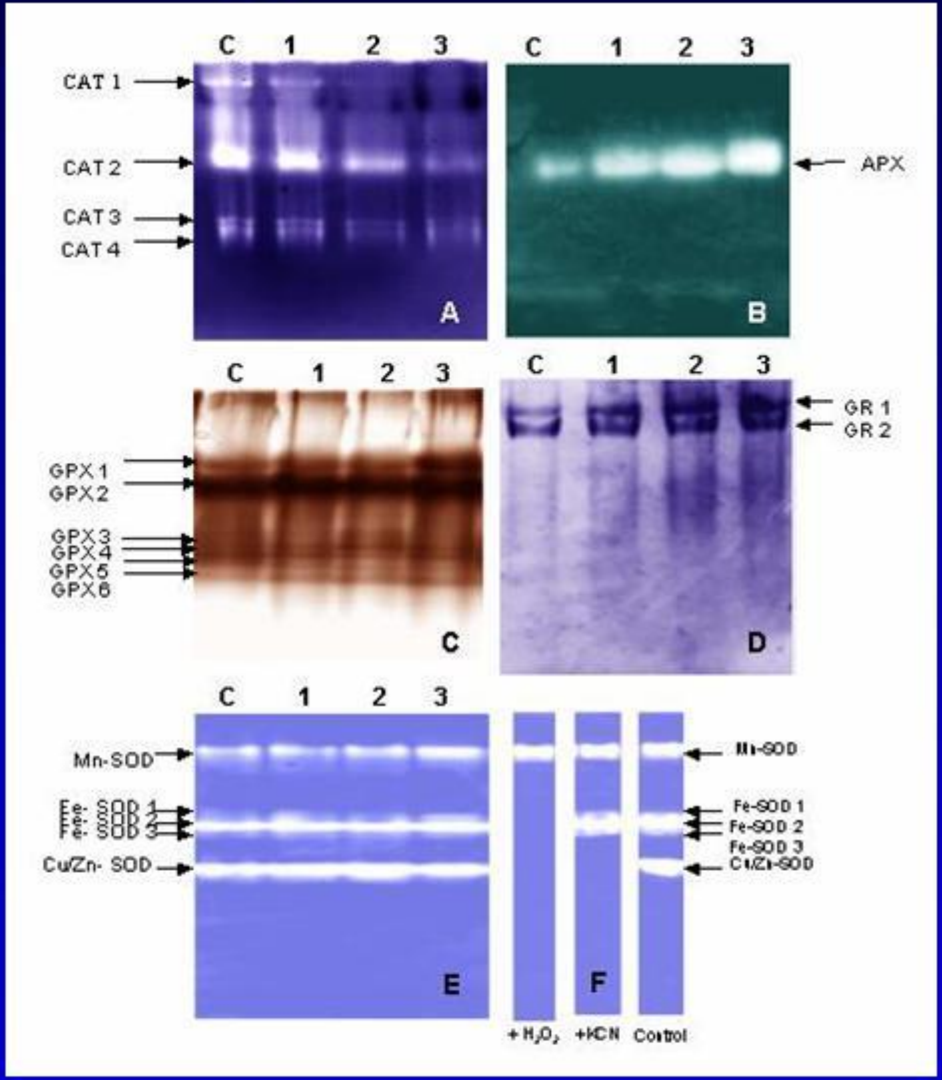
Effects of salt on growth, ion accumulation, photosynthesis and leaf anatomy of the mangrove, *Bruguiera parviflora*

Received: 15 October 2002 / Revised: 25 June 2003 / Accepted: 21 August 2003 / Published online: 1 November 2003

Abstract The effects of a range of salinity (0, 100, 200 and 400 mM NaCl) on growth, ion accumulation, photosynthesis and anatomical changes of leaves were studied in the mangrove, *Bruguiera parviflora* of the family Rhizophoraceae under hydroponically cultured conditions. The growth rates measured in terms of plant height, fresh and dry weight and leaf area were maximal in culture treated with 100 mM NaCl and decreased at higher concentrations. A significant increase of Na^+ content of leaves from 46.01 mmol m^{-2} in the absence of NaCl to 140.55 mmol m^{-2} in plants treated with 400 mM NaCl was recorded. The corresponding Cl^- contents were 26.92 mmol m^{-2} and 97.89 mmol m^{-2}. There was no significant alteration of the endogenous

tration. Stomatal and mesophyll conductance decreased by 49% and 52% respectively after 45 days in 400 mM NaCl compared with conductance in the absence of NaCl. Scanning electron microscope study revealed a decreased stomatal pore area (63%) in plants treated with 400 mM NaCl compared with untreated plants, which might be responsible for decreased stomatal conductance. Epidermal and mesophyll thickness and intercellular spaces decreased significantly in leaves after treatment with 400 mM NaCl compared with untreated leaves. These changes in mesophyll anatomy might have accounted for the decreased mesophyll conductance. We conclude that high salinity reduces photosynthesis in leaves of *B. parviflora*, primarily by reducing diffusion of CO_2 to the

Antioxidative defense systems against salt stress



J. Plant Physiology 161(5): 531-542 (2004)

ELSEVIER

J. Plant Physiol. 161. 531–542 (2004)
http://www.elsevier.de/jplhp

JOURNAL OF PLANT PHYSIOLOGY

Defense potentials to NaCl in a mangrove, *Bruguiera parviflora*: Differential changes of isoforms of some antioxidative enzymes

Asish Kumar Parida[1], Anath Bandhu Das[1,2]*, Prasanna Mohanty[2]

[1] National Institute for Plant Biodiversity Conservation and Research, Nayapalli, Bhubaneswar 751015, Orissa, India
[2] Regional Plant Resource Centre, Nayapalli, Bhubaneswar 751015, Orissa, India

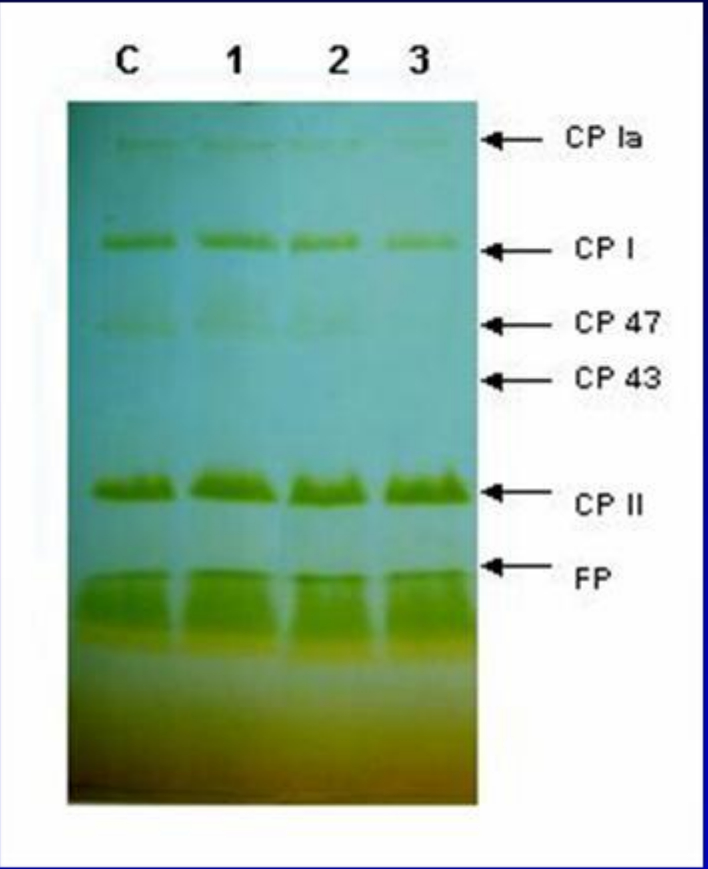
Received February 26, 2003 · Accepted August 28, 2003

Summary

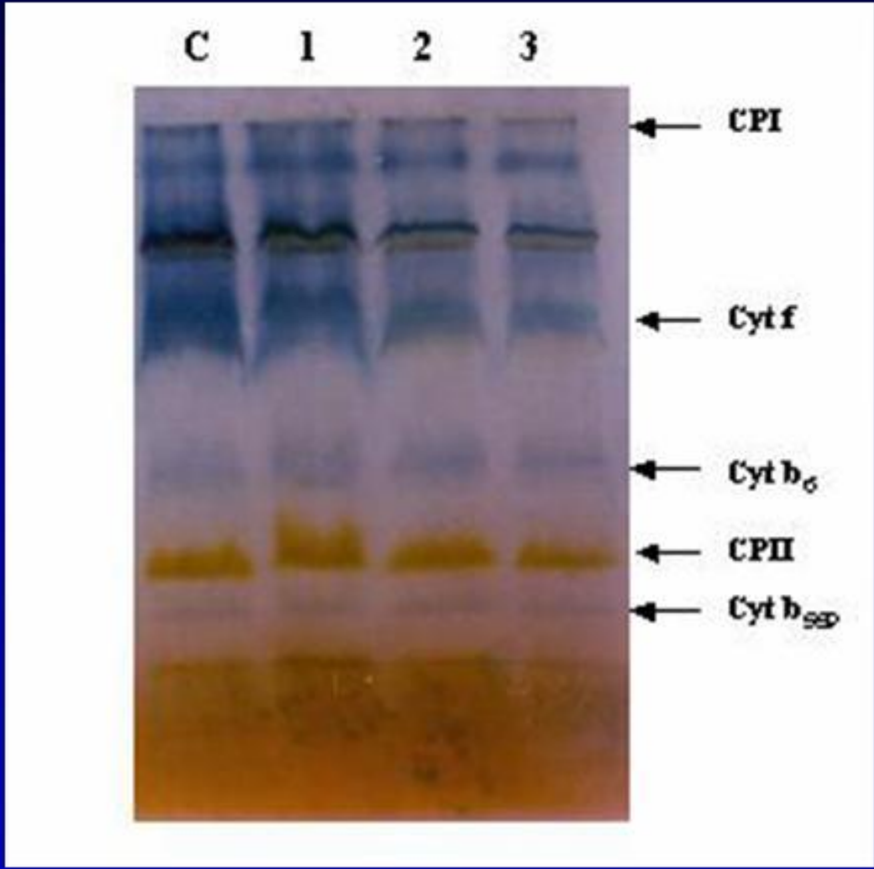
In order to assess the role of the antioxidative defense system against salt treatment, the activities of some antioxidative enzymes and levels of antioxidants were monitored in a true mangrove, *Bruguiera parviflora*, subjected to varying levels of NaCl under hydroponic culture. In the leaves of *B. parviflora*, salt treatment preferentially enhanced the content of H_2O_2 as well as the activity of ascorbate peroxidase (APX), guaiacol peroxidase (GPX), glutathione reductase (GR), and superoxide dismutase (SOD), whereas it induced the decrease of total ascorbate and glutathione (GSH+GSSG) content as well as catalase (CAT) activity. Analysis of isoforms of antioxidative enzymes by native PAGE and activity staining revealed that leaves of *B. parviflora* had one isoform each of Mn-SOD and Cu/Zn-SOD and three isoforms of Fe-SOD. Expression of Mn-SOD and Fe-SOD-2 was preferentially elevated by NaCl. Similarly, out of the six isoforms of GPX, the GPX-1, 2, 3 and 6 were enhanced by salt treatment but the levels of GPX-4 and -5 changed minimally as compared to those of a control. Activity staining gel revealed only one prominent isoform of APX and two isoforms of GR (GR-1 and GR-2), all of these isoforms increased upon salt exposure. Four CAT-isoforms were identified, among which the prominent CAT-2 isoform level was maximally reduced, suggesting differential down regulation of CAT isoforms by NaCl. The concentrations of malondialdehyde (MDA), a product of lipid peroxidation, remained unchanged in leaves of the plant treated with different concentrations of NaCl. This suggests that plants are protected against activated oxygen species by the elevated levels of certain antioxidative enzymes, thus avoiding lipid peroxidation during salt exposure. The differential changes in the levels of the isoforms due to NaCl treatment may be useful as markers for recognizing salt tolerance in mangroves.

Key words: antioxidative enzymes – *Bruguiera parviflora* – hydroponic culture – lipid peroxidation – mangrove – sodium chloride

Changes in pigment protein complexes in thylakoids



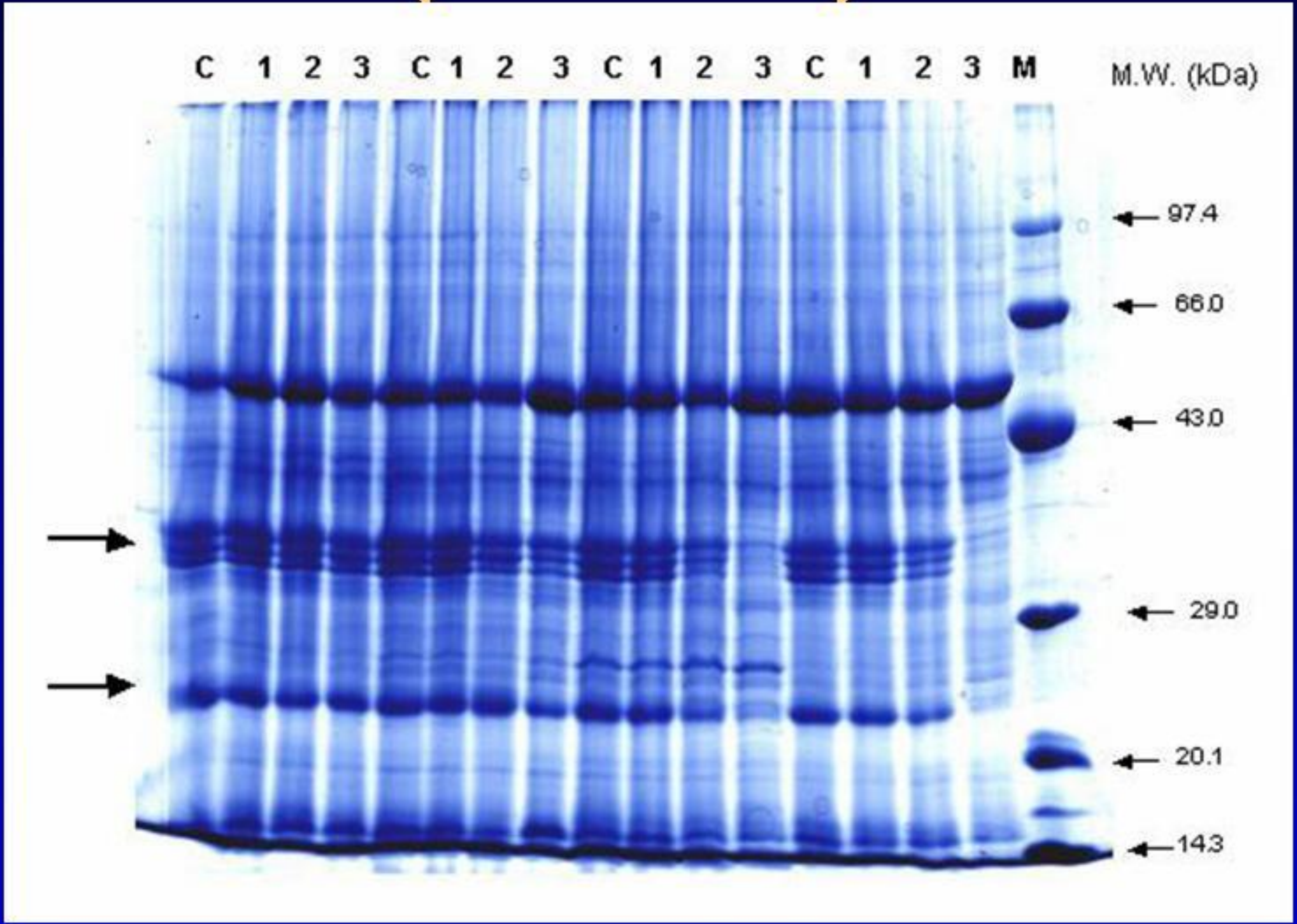
Green gel



Haem staining

Marine Biology 141:415-422 (2002)

Salt stress marker protein (~23 kDa)



Z. Natureforsch 59(c):408-414(2004)

ELSEVIER

Aquatic Botany 80 (2004) 77–87

Aquatic botany

www.elsevier.com/locate/aquabot

Effects of salinity on biochemical components of the mangrove, *Aegiceras corniculatum*

Asish Kumar Parida[a], Anath Bandhu Das[a,b,*], Yukika Sanada[c], Prasanna Mohanty[b]

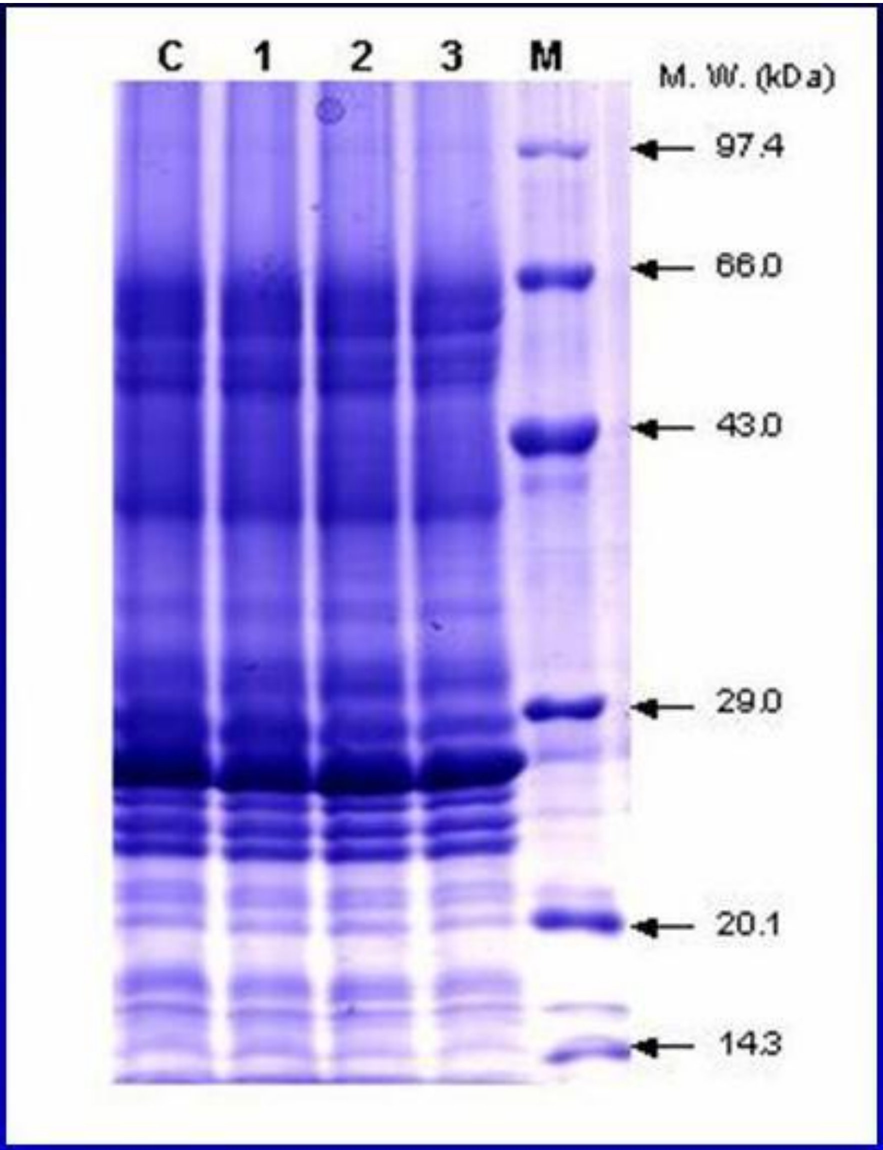
[a]*National Institute for Plant Biodiversity Conservation and Research and Regional Plant Resource Centre, Bhubaneswar 751015, Orissa, India*
[b]*Regional Plant Resource Centre, Bhubaneswar 751015, Orissa, India*
[c]*Department of Biology, Faculty of Science, Kanazawa University, Kakuma, Kanazawa 920-1192, Japan*

Received 23 September 2003; received in revised form 6 July 2004; accepted 6 July 2004

Abstract

Salt induced biochemical changes were studied in hydroponically grown plants of a salt secrector mangrove, *Aegiceras corniculatum* (Myrsinaceae). Total Chl content decreased in 250 mM NaCl over the 30 d treatment period. The Chl *a:b* ratio remained unchanged in leaves, but carotenoids showed a 1.6-fold decrease. Total sugar content decreased to half in 250 mM NaCl and starch content increased by 174%. Leaf protein content decreased slightly and SDS-PAGE analysis showed nearly identical protein profiles in control and salt treated samples, which suggests that NaCl did not alter protein synthesis or proteolytic activity. The total free amino acid pool as well as the proline content

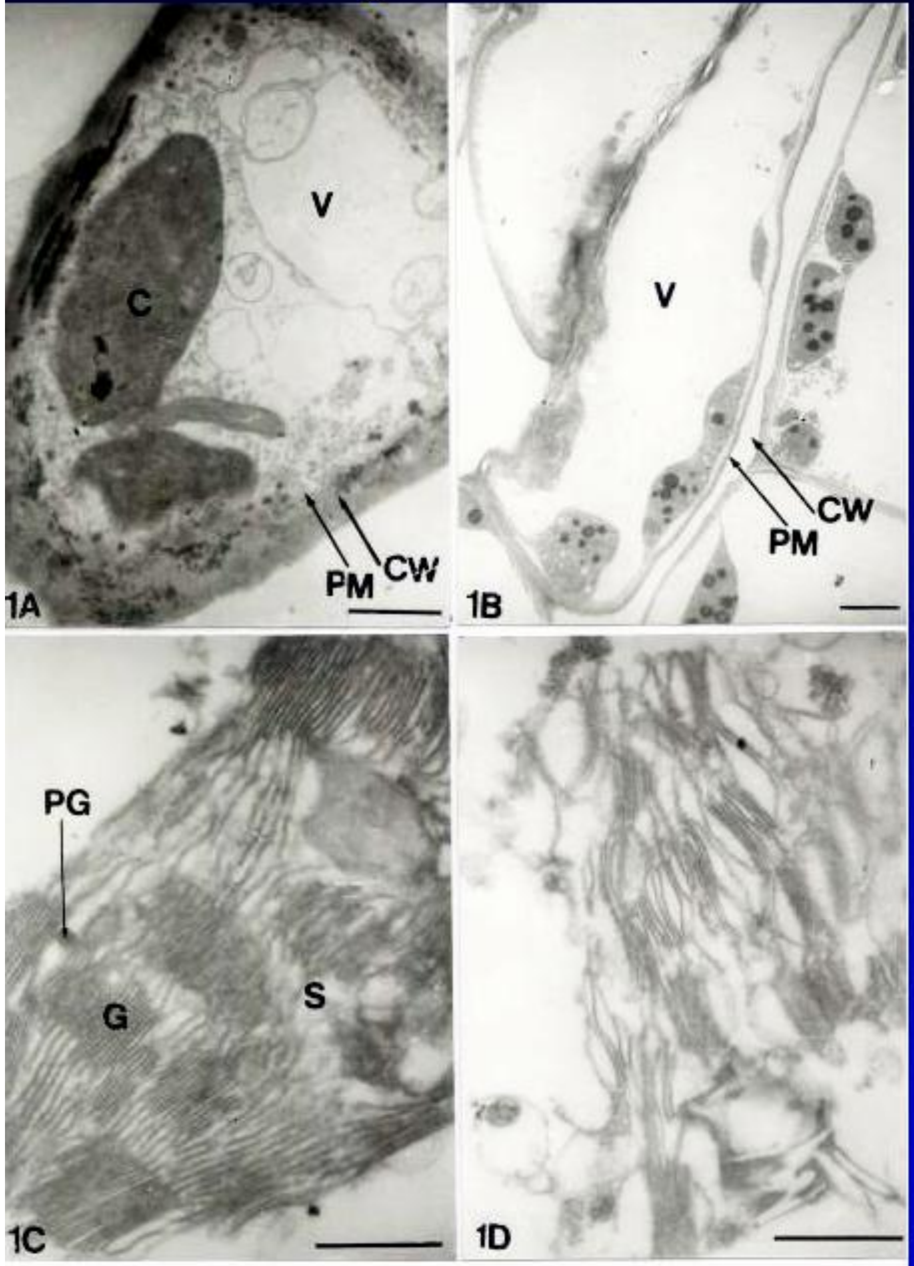
Thylakoid Polypeptide Change

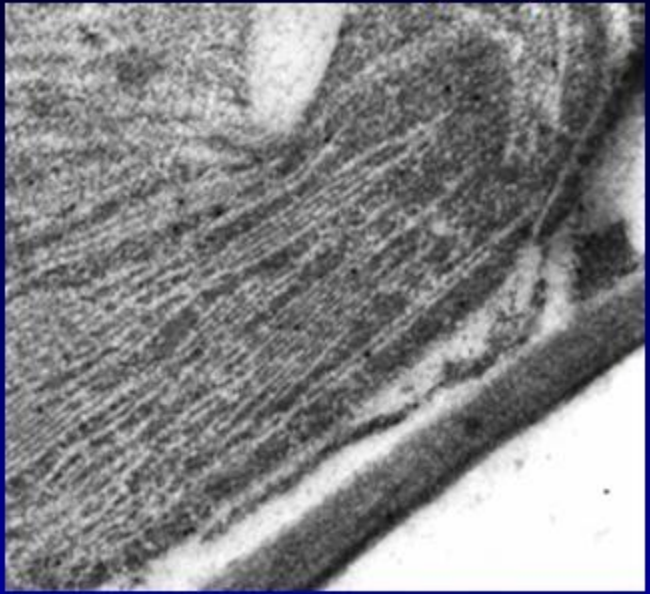


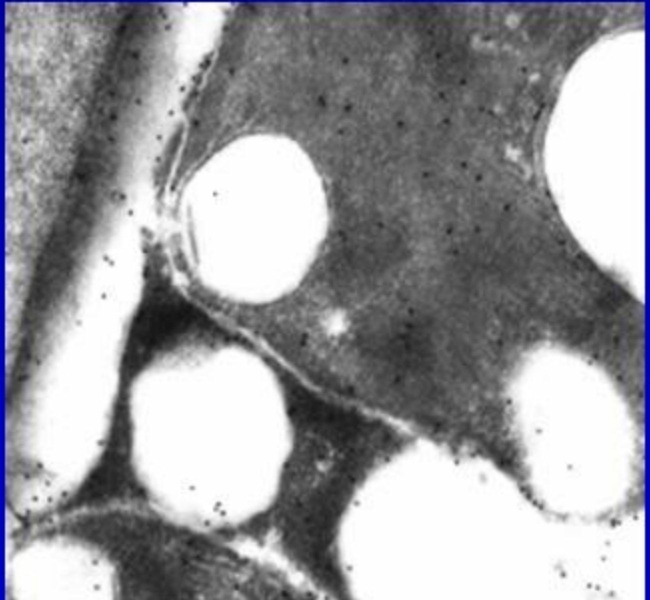
Z. Natureforsch 59(c):408-414(2004)

Effects NaCl on thylakoids structure of a mangrove

B. parviflora Tree Structure and Function 18:167-174 (2004)







Localization of 23kDa protein through immunogold assay

Planta 1995 online ISSN:0032-0935

Planta (2005) 221: 135–140
DOI 10.1007/s00425-004-1415-2

ORIGINAL ARTICLE

Asish Kumar Parida · Bhabatosh Mittra
Anath Bandhu Das · Taposh Kumar Das
Prasanna Mohanty

High salinity reduces the content of a highly abundant 23-kDa protein of the mangrove *Bruguiera parviflora*

Received: 27 April 2004 / Accepted: 11 September 2004 / Published online: 3 December 2004

Abstract A significant decrease in the amount of a protein, whose migration in two-dimensional gel electrophoresis corresponds to an apparent molecular mass of 23 kDa and pI = 6.5, was observed in leaves of NaCl-treated *Bruguiera parviflora* (Roxb.) Wt. & Arn. ex Griff. seedlings. This particular salt-sensitive protein, designated as SSP-23, almost disappeared after 45 days of treatment in 400 mM NaCl as compared to untreated seedlings (0 mM NaCl) where the presence of the protein was significant. A polyclonal antibody raised against the 23-kDa protein was used to determine the subcellular localization of this protein in leaves by cross-reaction with proteins from isolated chloroplasts, mitochondria, peroxisomes and cytosol fractions on Western blots. SSP-23 was confirmed to be localized in the cytosol by immunoblotting. The disappearance of SSP-23 as a result of high NaCl treatment suggests that this protein is salt-sensitive and has a possible role in salt adaptation.

Abbreviations 2-D: Two dimensional · PAGE: Polyacrylamide gel electrophoresis · SDS: Sodium dodecyl sulfate · SSP: Salt-sensitive protein

Introduction

Salt stress negatively impacts agricultural yield throughout the world, affecting production whether it is for subsistence or economic gain (Flowers 2004). To cope with salt stress, plants respond with physiological and biochemical changes designed to retain water in spite of the high external osmoticum and to maintain photosynthetic activity even when stomatal opening is reduced to counter water loss.

Mangroves are an assortment of woody trees and shrubs, which flourish in an inhospitable zone between

J. Plant Biol., Vol. **33** (1&2), April & August, 2006, pp. 133–138.

ARTICLE

A Salt Responsive Leaf Protein, SSP23 in Tree Mangrove Bruguiera: Localization in Leaf Tissue by Immunogold Labelling

Bhabatosh Mitra[1], Anath Bandhu Das[2], T. K. Das[3], A. Parida[2], S. Mishra[2] and Prasanna Mohanty[2,4,*]

[1]Bioscience and Biotechnology, F.M. University, Balasore 756 009, India
[2]Regional Plant Resource Centre, Nayapalli, Bhubaneswar 751 015, India
[3]Electron Microscopy Department, AIIMS, New Delhi 110 029, India
[4]Jawaharlal Nehru University, New Delhi 110 067, India

MS received 27 October 2005; accepted 14 March 2006

Eight-week-old tree mangrove *Bruguiera parviflora* plants, raised from the propagules were hydroponically maintained in Hoagland medium and were subjected to NaCl treatments for 45 days to high (400 mM) NaCl exposure. A low molecular weight (23 kDa) highly abundant soluble protein, designated as salt sensitive protein (SSP23), decreased significantly, among other biochemical changes by salt treatment. Removal of NaCl from the Hoagland medium caused the reappearance of SSP23. The reversibility in the relative abundance of SSP23 reflected its salt sensitive characteristics. Localization of SSP23 in the leaf tissue was probed by raising a polyclonol antibody against the purified SSP23 and viewed under transmission electron microscopy using immunogold labelling technique. Our results demonstrated that SSP23 to be present in the chloroplasts, besides inner membranes and periphery of vacuoles of the mesophyll cells, and it decreased significantly on high salinity conditions. The number of immunogold particles decreased from ~ 245/μm^2 in control to 47/μm^2 in 400 mM NaCl-treated samples. We, thus, consider protein SSP23 as a useful indicator for salt response in mangroves and possibly in other plants. Further, molecular identity of SSP23 needs to be characterized for its use as a salt sensitivity indicator in plants.

BIOLOGIA PLANTARUM 52 (2): 343-346, 2008

BRIEF COMMUNICATION

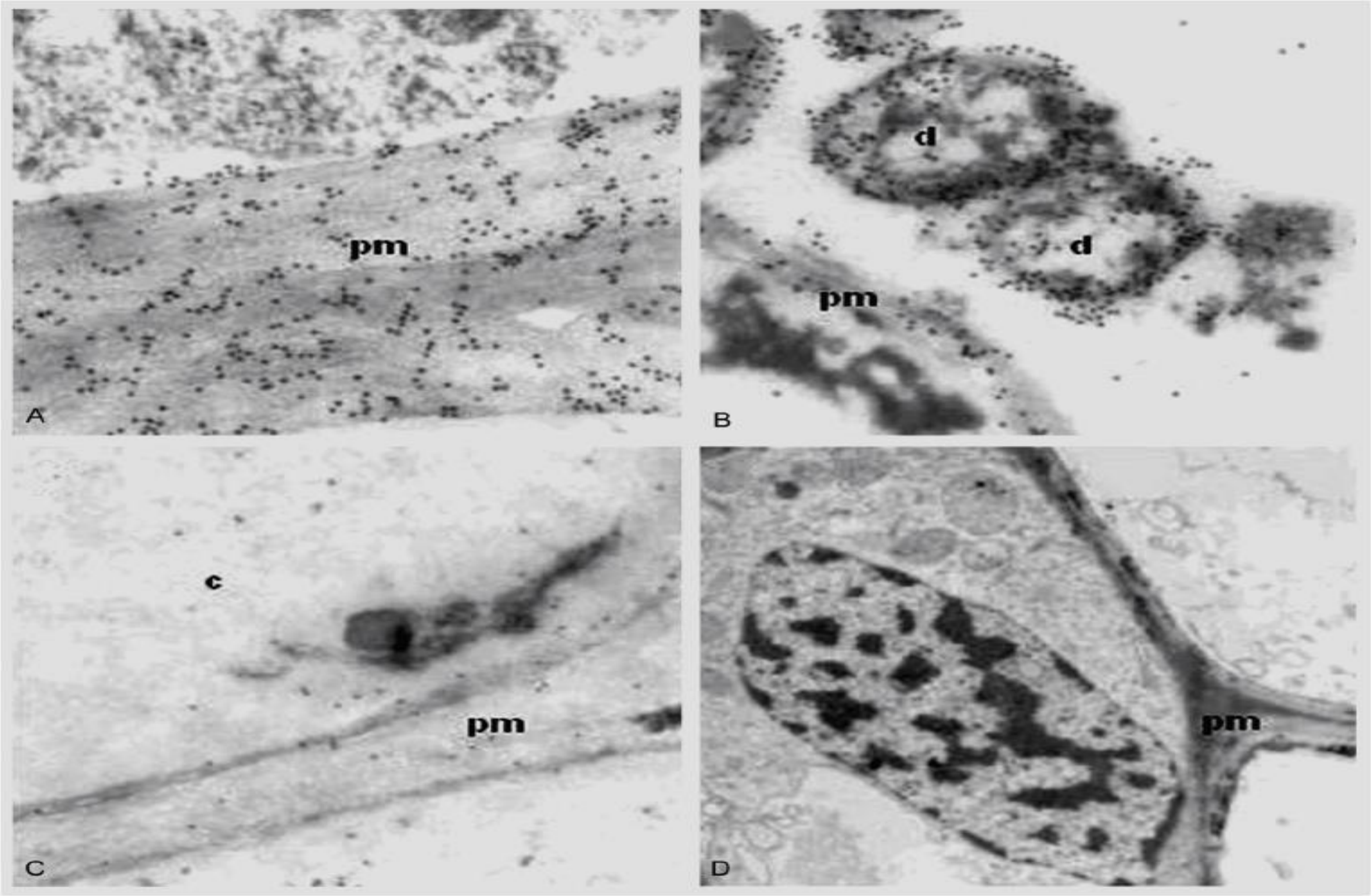
A novel cadmium induced protein in wheat: characterization and localization in root tissue

B. MITTRA[1]*, S. SHARMA[2], A.B. DAS[3], S.L. HENRY[4], T.K. DAS[5], P. GHOSH[6], S. GHOSH[6] and P. MOHANTY[3,7]

Department of Biosciences and Biotechnology, Fakir Mohan University, Vayasa Vihar, Balasore-756019, Orissa, India[1]
Department of Biophysics, All India Institute of Medical Sciences, New Delhi-110019, India[2]
Cytogenetics Laboratory, Regional Plant Resource Center, Nayapalli, Bhubaneswar-751015, Orissa, India[3]
Department of Plant Sciences, Institute of Bio-medical and Life Sciences, University of Glasgow, UK[4]
Electron Microscopic Facility, All India Institute of Medical Sciences, New Delhi-110019, India[5]
Department of Biophysics, University of Delhi, South Campus, New Delhi - 110021, India[6]
School of LifeSciences, University of Hyderabad, Hyderabad 500046, Andhra Pradesh, India[7]

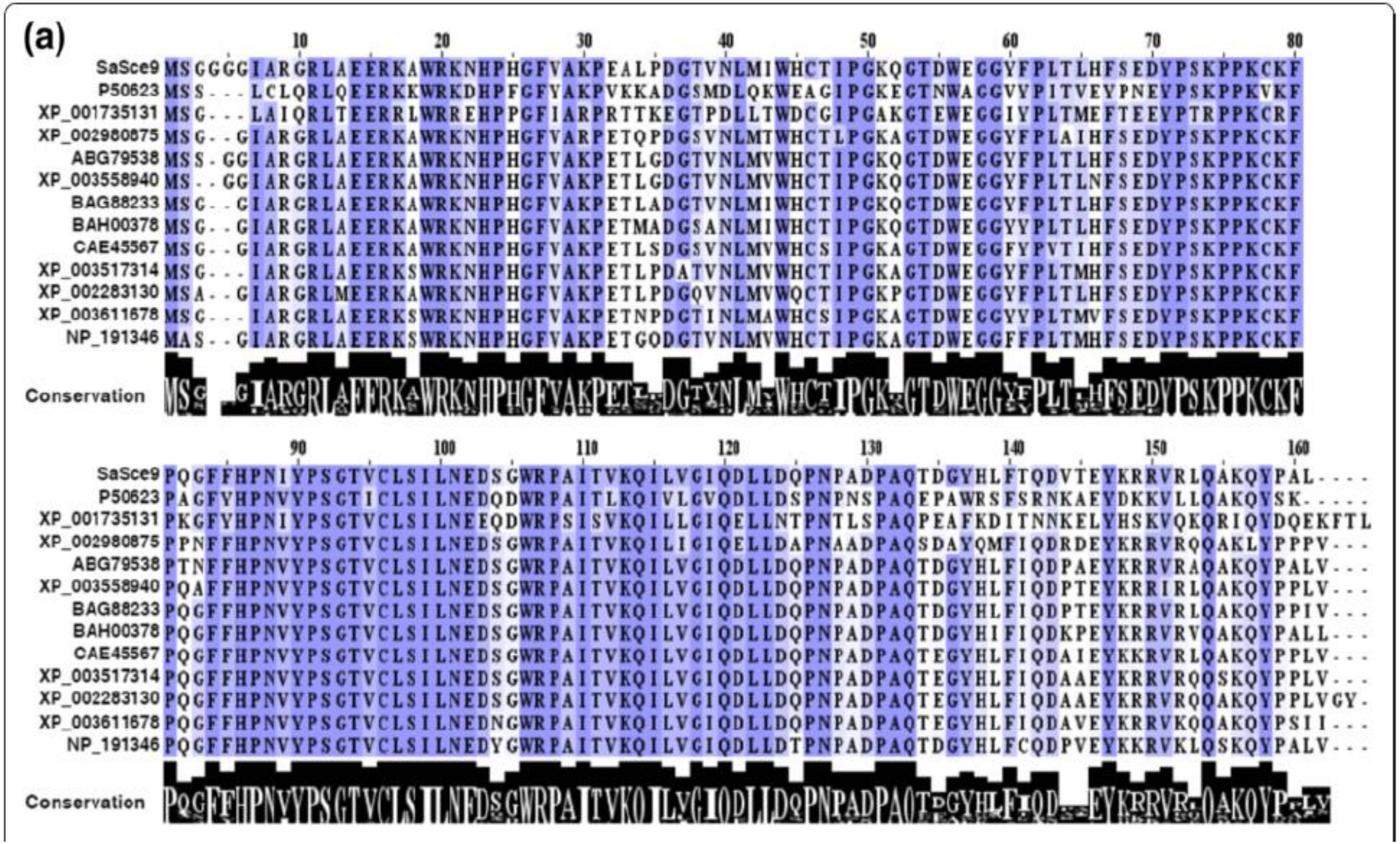
Abstract

A 51-kDa soluble protein was over-expressed in wheat (*Triticum aestivum*) seedlings by the treatment of seeds before germination with 50 μM $CdCl_2$ for 48 h and subsequently washed off Cd^{2+}. This protein designated as Cd stress associated protein (CSAP), was purified. Polyclonal antibody was raised against CSAP for localizing the protein in root tissue of treated and control seedlings. It was observed that CSAP was located below the plasma membrane and outer periphery of the tonoplast. This unique type of organized localization of CSAP is suggestive of defensive role against metal phytotoxicity. N-terminal analysis of CSAP and expressed sequence tags (EST) database search of wheat sequences suggests that this protein has not been reported earlier in higher plants.



smission electron micrographs showing localization of CSAP in root tissues. *A* - Cd^{2+} treated section sho
·5 000), *B* - labelling at the outer periphery of the vacuolar membranes in treated section (×45 000), *C* - gold
sue (×24 000), *D* - Cd^{2+}-treated root section in which anti-CSAP-antiserum is replaced with the pre-immune
:he number of labelled gold particles were 95.75 ± 26.69 (Fig. 2*A*), 83.62 ± 31.73 (Fig. 2*B*) and 6.18
- cytoplasm, pm - plasma membrane, d - dictyosome.

Salt stress inducible SUMO conjugating enzyme gene



SaSce9 gene in halophyte Spartina

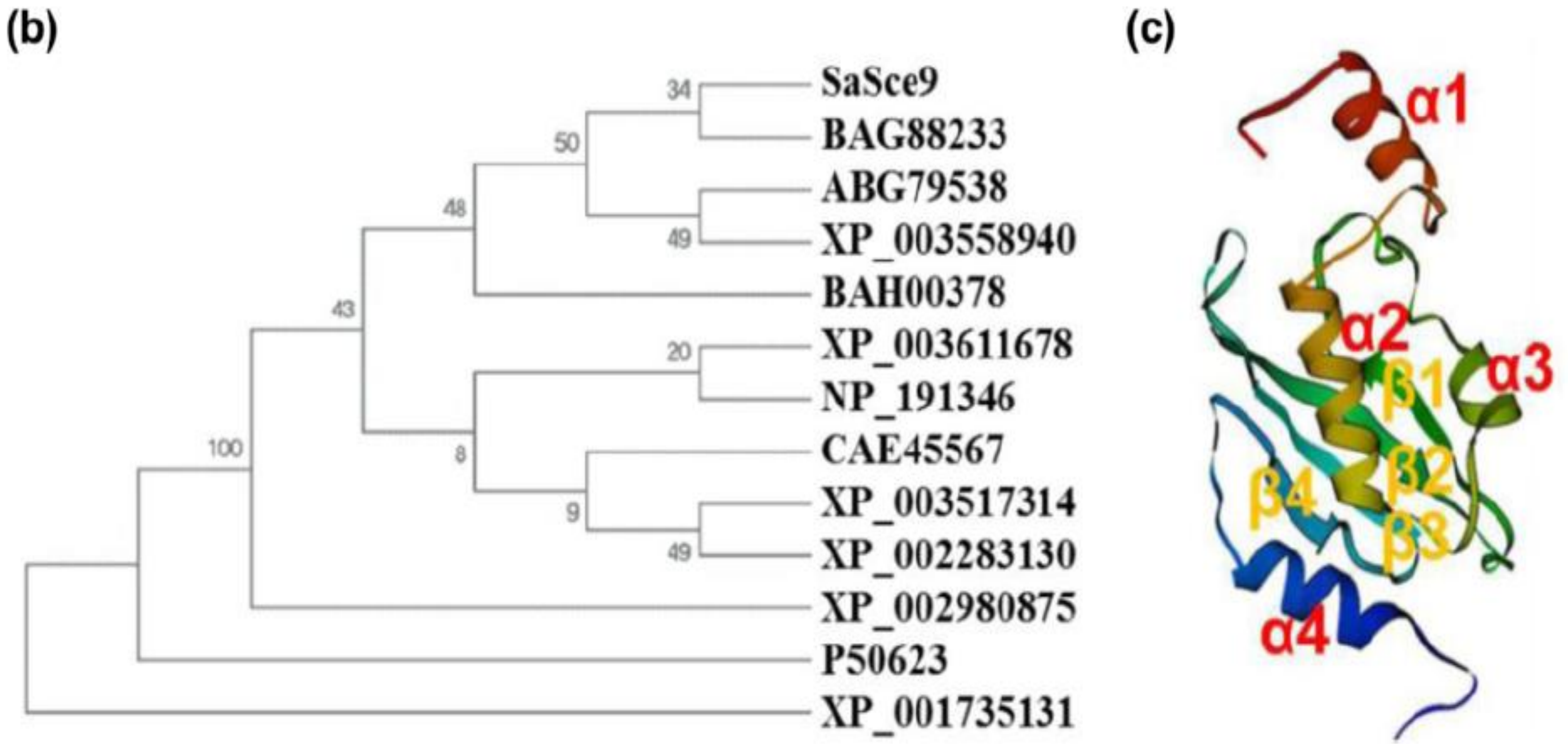
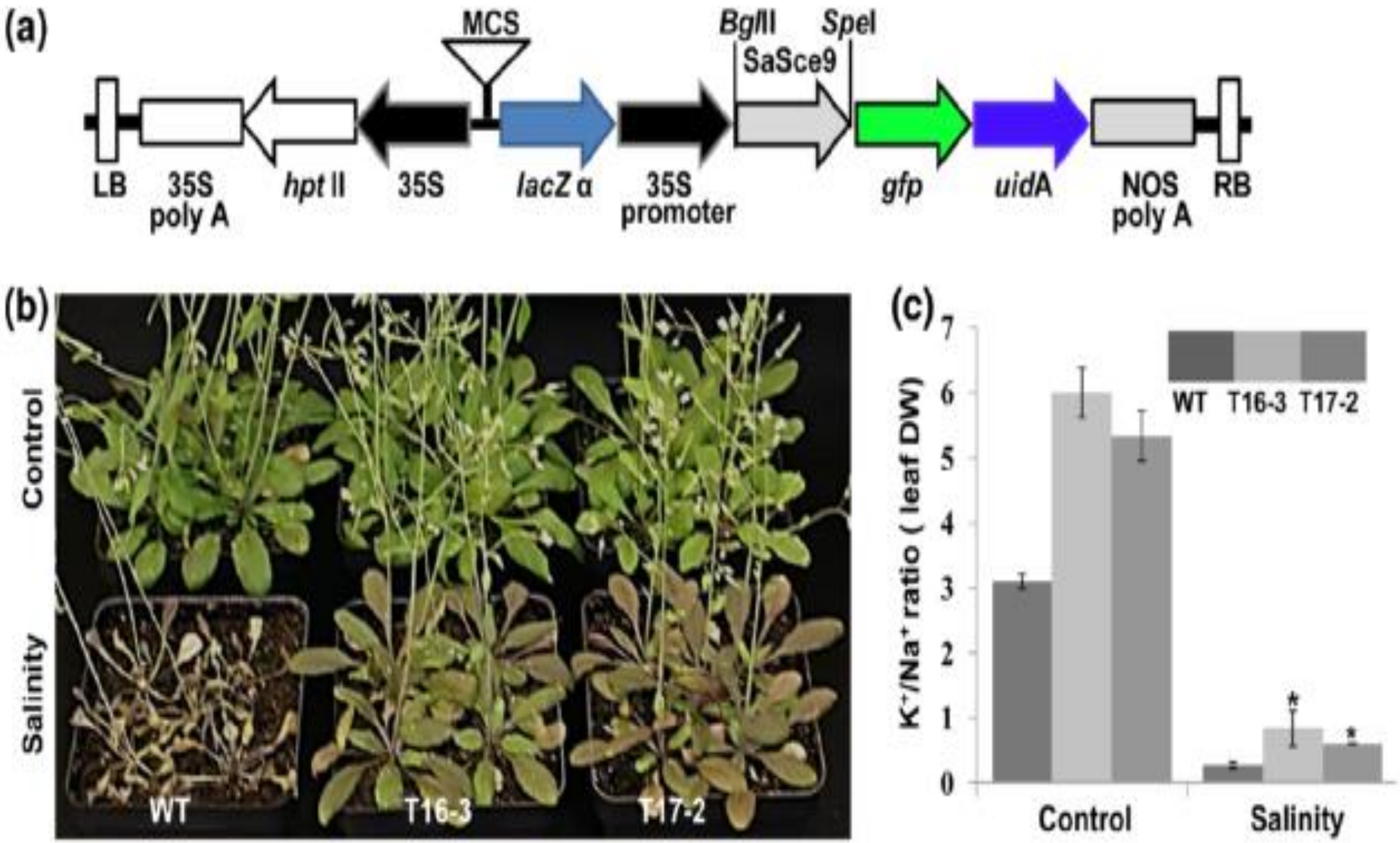


Figure 1 Multiple sequence alignments, phylogenetic analysis, and predicted tertiary structure of *SaSce9* protein. (a) Multiple sequence

Transgenics *Arabidopsis with* SaSce9 gene



Salt Stress Induced Variation in DNA Methylation Pattern in Rice Genotypes

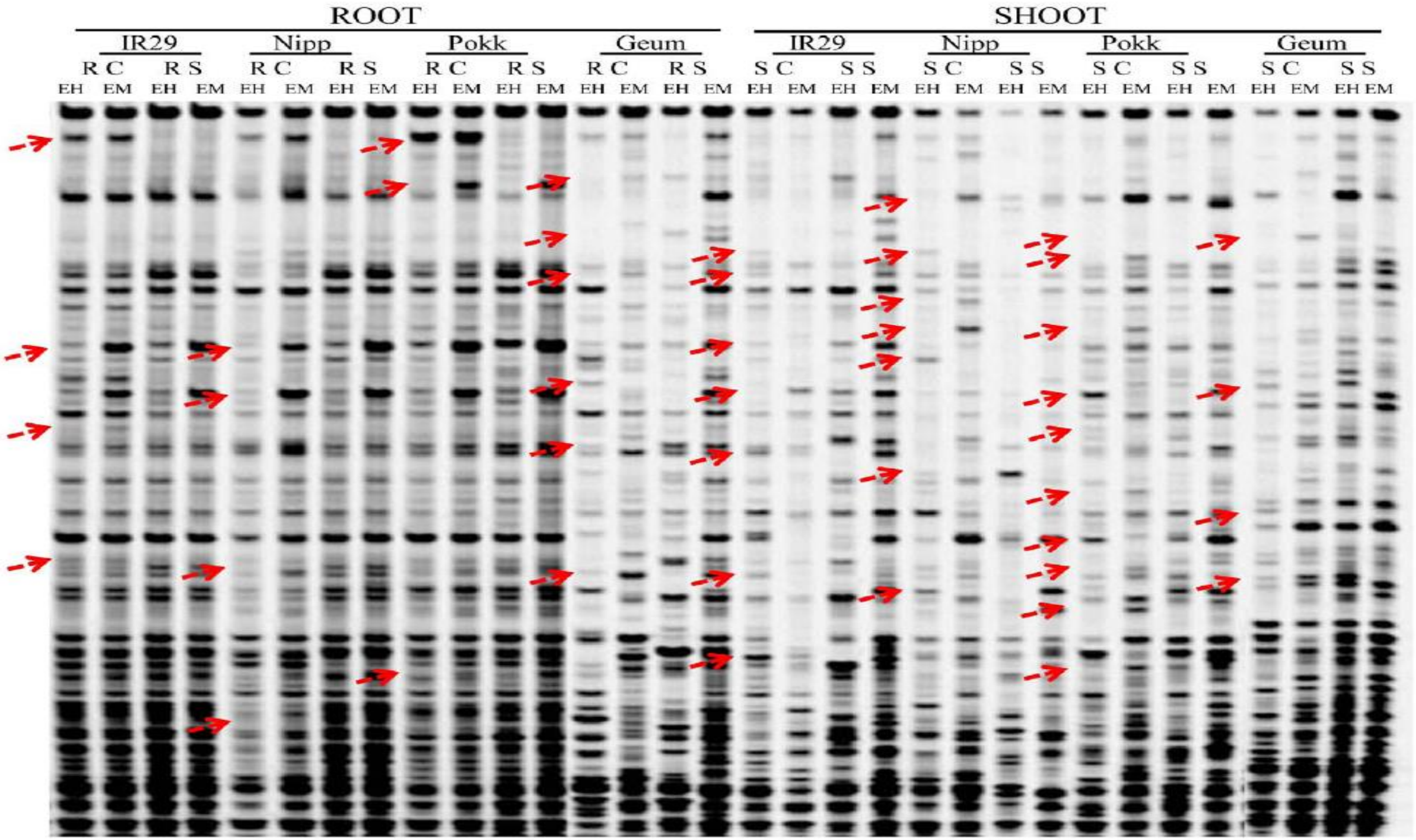


Figure 1. A representative MSAP gel using the primer combination *Eco*RI-ACG/*Msp*I-AATC. Both control and salinity stressed root and shoot of rice genotypes, IR29, Nipponbare (Nipp), Pokkali (Pokk), Geumgangbyeo (Geum) were used for MSAP analysis. EH and EM refer to digestion with *Eco*RI+*Hpa*II and *Eco*RI+*Msp*I, respectively. RC: root control; RS: root stress; SC: shoot control; SS: shoot stress.

doi:10.1371/journal.pone.0040203.g001

Chapter 16
Bioprospecting and Genetic Engineering of Mangrove Genes to Enhance Salinity Tolerance in Crop Plants

Anath Bandhu Das

A. B. Das (✉)
Molecular Genetics Laboratory, Department of Agricultural Biotechnology, Orissa University of Agriculture and Technology, Bhubaneswar 751003, Orissa, India
e-mail: a_b_das@hotmail.com

S. M. Jain and S. Dutta Gupta (eds.), *Biotechnology of Neglected and Underutilized Crops*, DOI: 10.1007/978-94-007-5500-0_16,

Abstract Salinity in agricultural land is a major problem world wide, placing a severe constraint on crop growth and productivity in many regions and increased salinization of arable land is expected to have devastating global effects. Though plants vary in their sensitivity to salt stress, high salinity causes water deficit and ion toxicity in many plant species. Considerable efforts have therefore been made to investigate how genes respond to salt stress in various plants by using several approaches, including proteomics. Proteomic approaches for identifying proteins that are regulated in response to salt stress are becoming common in the post-

Gyana Ranjan Rout
Anath Bandhu Das *Editors*

Molecular Stress Physiology of Plants

Springer

Genet Resour Crop Evol
DOI 10.1007/s10722-008-9390-2

RESEARCH ARTICLE

Use and variation of *Pandanus tectorius* Parkinson (*P. fascicularis* Lam.) along the coastline of Orissa, India

Kamal K. Panda · Anath B. Das · Brahma B. Panda

Received: 23 March 2008 / Accepted: 10 November 2008

Abstract *Pandanus tectorius* Parkinson (*P. fascicularis* Lam.) of the family Pandanaceae constitutes one of the major bioresources of Ganjam coast, Orissa; used mainly in small scale perfume industry for aromatic compound extracted from the male inflores-

branches, with populations II and III in one and the rest populations in the other branch of the phylogenetic tree. It was important to note that the unique populations II and III confined to the Ganjam coast of Orissa having RAPD markers; OPA 09–940 bp, OPA 09–

Published online: 21 January 2009

3:877(18). 1924; Fischer in Gamble, Fl. Madras 3:570(1095). 1931; which is currently being followed in this part of the Indian Subcontinent. The above

Fig. 1 A picture of *P. tectorius* Parkinson (*P. fascicularis* Lam.) showing a male inflorescence

Fig. 2 Map showing the sampling sites viz. I. Palasa, II. Tulu/Indrakhi, III. Chatrapur, VI. Chilika,V. Puri/Konark, VI. Paradeep/Ersama and VII. Balesore along the coast of Orissa from where the populations of *P. tectorius* investigated in the present study were obtained

Fig. 6 Dendrogram showing genetic divergence and affinity among populations I–VII of *P. tectorius* along the coastline of Orissa as revealed by RAPD analysis

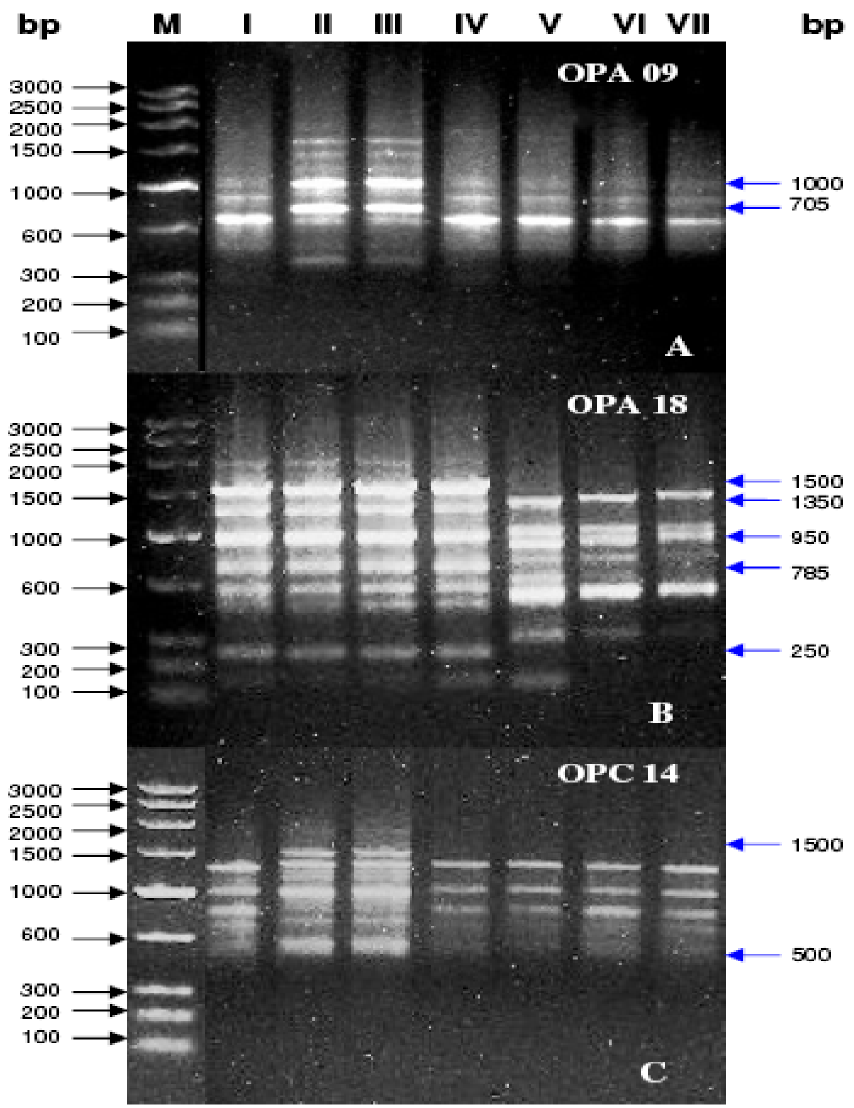


Fig. 5 RAPD profile of populations I–VII of *P. tectorius* along the coastline of Orissa showing amplicons OPA 09–940 bp and OPA-705 bp in populations II and III (**a**), amplicons OPA 18–1,500 bp, OPA.18–1,350, OPA 18–250 in populations I–IV and OPA 18–950 bp in populations V-VII (**b**), OPC 14–1,500 and OPC 14–500 bp in populations II and III (**c**)

constituting a sub-cluster. It was important to note a few population specific RAPD markers identified in the present study (Fig. 5). For instance OPA 18 whereas had amplified DNA bands of size 1,500 bp and 250 bp specific to populations I–IV, amplified bands of size 1,350 bp and 950 bp in populations V–VII. Likewise the amplicon of size 600 bp produced by OPN 18 were found in populations I–IV only. Amplicons of size 1,000 bp and 400 bp produced by OPD 18 were restricted to populations I–III. Notably, the RAPD markers OPA 09–940 bp, OPA 09–705 bp, OPC 14–1,500 bp, OPC 14–700 bp, OPC 20–1,475 bp, OPC 20–1,350 bp, OPC 20–920 bp and OPC 20–700 bp; were all associated with populations II and III only. Phytochemical analysis of the aroma (kewda oil) from populations I, II, III or V (Table 4) did not show any remarkable differences with respect to the major constituents, 2-phenylethyl methyl ether (PEME) and terpinen-4-ol. The blend of the present 14 major and minor photochemicals is reportedly contributed to the characteristic order of the aroma (Rao 2000). It may be noted that popopulations II and III of *P. tectorius* belonging to the region of Ganjam coast or the 'Kewda belt' that have been supporting the perfume based small scale industry or economic activities (Panda et al. 2007), which was clearly distinguished from the rest of the populations on the basis of RAPD-analysis and placed together as a separate group in the dendogram (Fig. 6). The fact that the plant that follows vegetative propagation with restricted gene-flow pointed to the possible role of regional eco-geogrpahy in the underlying genetic

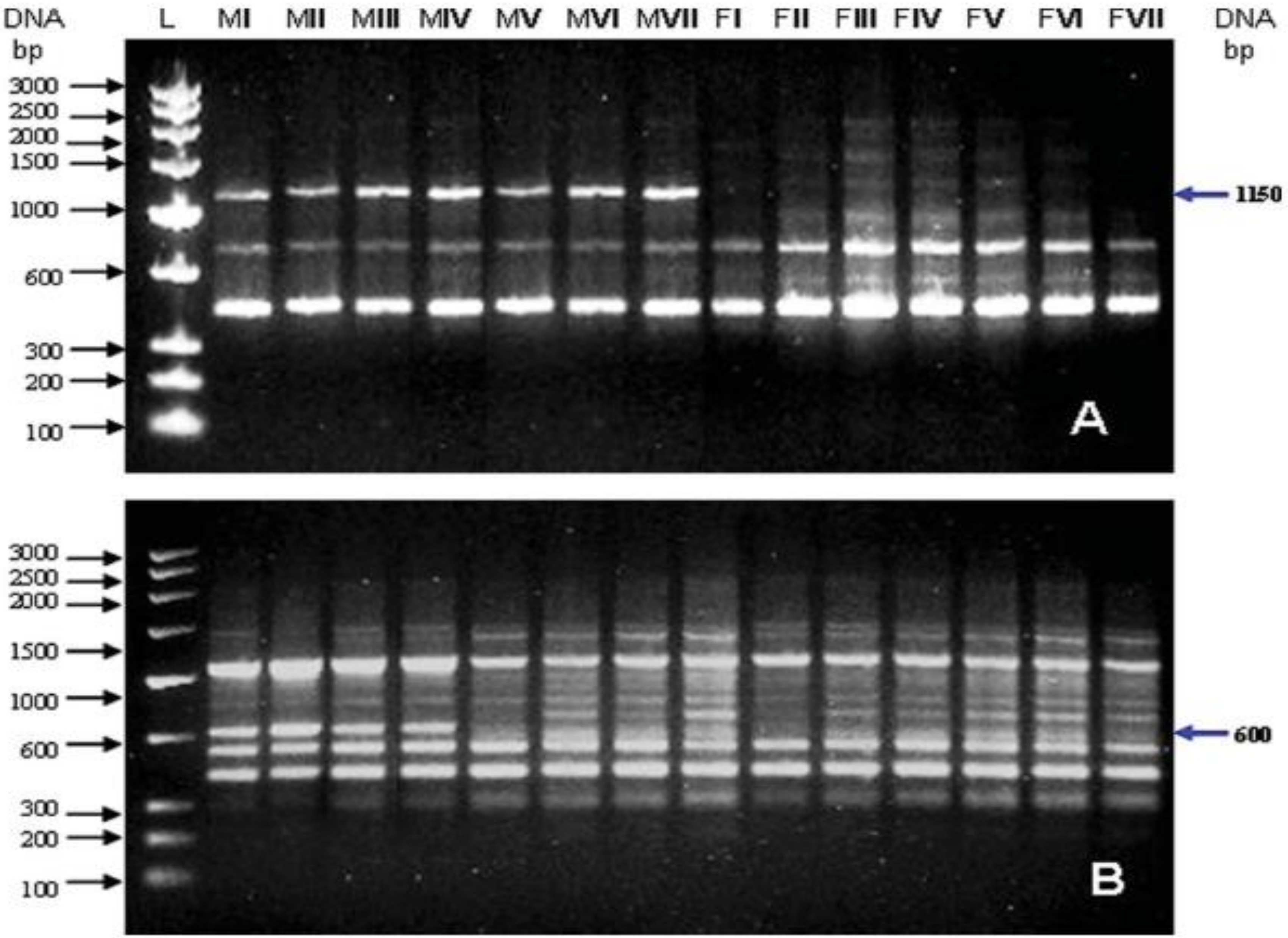
International Journal of Biodiversity Science, Ecosystem Services & Management
Vol. 6, Nos. 1–2, March–June 2010, 28–34

Use of RAPD markers to detect sex differences in *Pandanus tectorius* Parkinson, an important bioresource plant in Orissa, India

Kamal K. Panda[a], Biswajit Sahoo[a], Anath B. Das[b†] and Brahma B. Panda[a*]

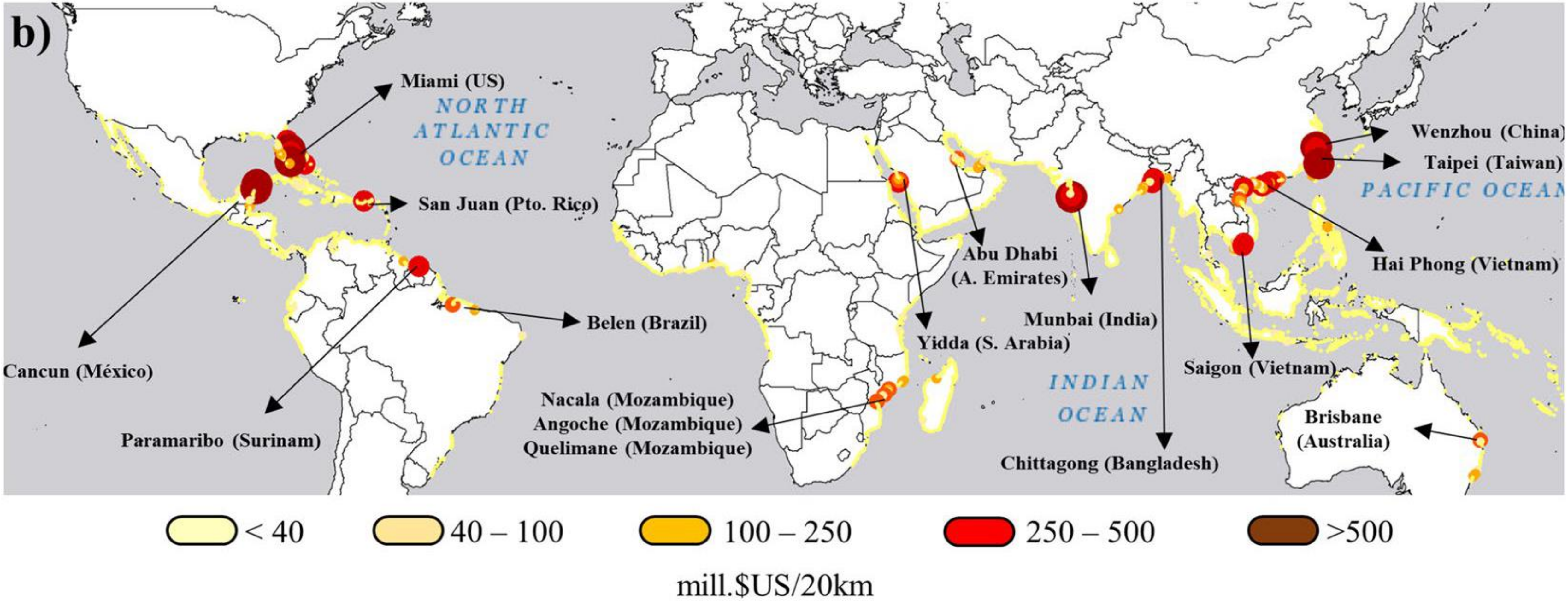
[a]*Molecular Biology and Genomics Laboratory, Department of Botany, Berhampur University, Berhampur 760 007, India;* [b]*Cytogenetics Laboratory, Regional Plant Resource Centre, Bhubaneswar 751015, India*

Pandanus tectorius Parkinson (= *P. fascicularis* Lam.) is a dominant perennial dioecious plant of coastal areas of India. Aromatic inflorescences harvested from male plants constitute the raw material that supports a flourishing perfume industry confined to the Ganjam coast on the east coast of south Orissa. The plant is vegetatively propagated, and sex is only clear after 5–7 years when plants from stem cuttings start to flower. Early determination of the sex of the plant was examined through analysis of somatic chromosome compliment, genomic DNA content and random amplified polymorphic DNA (RAPD) analysis in seven populations of *P. tectorius* from the coast of Orissa. Whereas the chromosome complement ($2n = 60$) failed to reveal any differences, the 4C DNA amount indicated that the genome of female plants [6.15 pg = 5935 mega base pair (Mbp)] was significantly larger than that of male plants (5.09 pg = 4912 Mbp). Motivated by the perfume economy, local farmers presently look upon *P. tectorius* as a cash crop and tend to conserve and propagate male genotypes of several populations along the coast of Ganjam. The two RAPD markers, 1150 and 600 bp, amplified with primers OPB-12 and OPN-18, respectively, may together be useful to conserve elite genotypes in natural populations of *P. tectorius*.



Comparative RAPD profiles of male (M) and female (F) populations I–VII of *P. tectorius* along the coastline of
cific markers 1150 and 600 bp amplified by OPA-12 (A) and OPN-18 (B), respectively. L indicates DNA ladder ir

Annual expected benefits provided by mangroves to property per 20-km coastal unit



Global Benefits of Mangroves in Averted Flooding and Damages.

	Land flooded (x1000 km²)			People affected (million)			Property loss ($US billion)		
	With	Without	Benefit	With	Without	Benefit	With	Without	Benefit
Annual Expected	122	157	35	53	68	15	732	797	65
10-yr	176	221	45	82	103	21	1200	1293	93
25-yr	209	262	53	107	129	22	1558	1662	104
50-yr	249	318	69	138	166	28	1953	2092	139
100-yr	326	423	97	192	229	37	2714	2984	270

Country ranking. The countries receiving the greatest benefits from mangroves in averted land flooding and damages to people and property.

(a) Land [x1,000 km^2]			(b) People [million]			(c) Property [$US billion]			(d) Property/GDP [%]		
1	Cuba	3.92	1	Vietnam	7.02	1	United States	11.31	1	Belize	28.86
2	Vietnam	3.12	2	India	2.87	2	China	8.58	2	Suriname	21.35
3	Bahamas	2.47	3	Bangladesh	1.11	3	Taiwan	7.89	3	Mozambique	17.59
4	Cambodia	1.78	4	Philippines	0.61	4	India	7.84	4	Bahamas	13.72
5	India	1.63	5	China	0.52	5	Mexico	7.42	5	Anguilla	4.63
6	United States	1.42	6	Brazil	0.33	6	Vietnam	6.45	6	Guyana	4.57
7	Nicaragua	1.40	7	Nigeria	0.30	7	Mozambique	1.94	7	Madagascar	3.57
8	Mexico	1.13	8	Indonesia	0.25	8	Saudi Arabia	1.61	8	Guinea Bissau	3.24
9	Honduras	1.07	9	Mozambique	0.24	9	Bangladesh	1.56	9	Vietnam	3.14
10	Indonesia	0.84	10	Mexico	0.23	10	Bahamas	1.55	10	Turks and Caicos	2.57
11	Bangladesh	0.82	11	Ivory Coast	0.21	11	Philippines	1.00	11	Sierra Leone	2.02
12	Brazil	0.76	12	Thailand	0.18	12	Australia	0.79	12	Taiwan	1.71
13	Guyana	0.75	13	Ecuador	0.18	13	UAE	0.74	13	New Caledonia	1.16
14	Belize	0.71	14	Taiwan	0.17	14	Brazil	0.72	14	Solomon Islands	1.07
15	Madagascar	0.69	15	Pakistan	0.14	15	Suriname	0.70	15	Ant. & Barbuda	1.06

Threat of Mangroves for Emergence of Climate Change

- Disturbance resulting from extractive uses of mangrove trees and mangrove fauna.
- Disturbance resulting from changes in upland hydrology due to construction.
- Pollution of mangroves.
- Destruction of mangroves associated with reclamation for non-extractive uses.
- Impacts of climate change resulting from increases in CO_2 and sea level rise.

Ten Strategies Managers Can Apply to Promote Resilience

1) Apply risk-spreading strategies to address the uncertainties of climate change.
2) Identify and protect critical areas that are naturally positioned to survive climate change.
3) Manage human stresses on mangroves.
4) Establish greenbelts and buffer zones to allow for mangrove migration in response to sea-level rise, and to reduce impacts from adjacent land-use practices.
5) Restore degraded areas that have demonstrated resistance or resilience to climate change.

Ten Strategies Managers Can Apply to Promote Resilience

6) Understand and preserve connectivity between mangroves and sources of freshwater and sediment, and between mangroves and their associated habitats like coral reefs and seagrasses.

7) Establish baseline data and monitor the response of mangroves to climate change.

8) Implement adaptive strategies to compensate for changes in species ranges and environmental
conditions.

9) Develop alternative livelihoods for mangrove dependent communities as a means to reduce mangrove destruction.

10) Build partnerships with a variety of stakeholders to generate the necessary finances and support to respond to the impacts of climate change.

Climate Resilient rice

Screening of superior genotypes adaptable to high CO_2 and high temperature of air based on C assimilation

All the 16 rice genotypes responded positively to elevated CO2. Maximum net photosynthesis rate (Pn) was maximum for ORS 331 and minimum for ORS 321. The popular cv Lalat and Swarna showed significantly higher no. of reaction centres, but moderate Pn

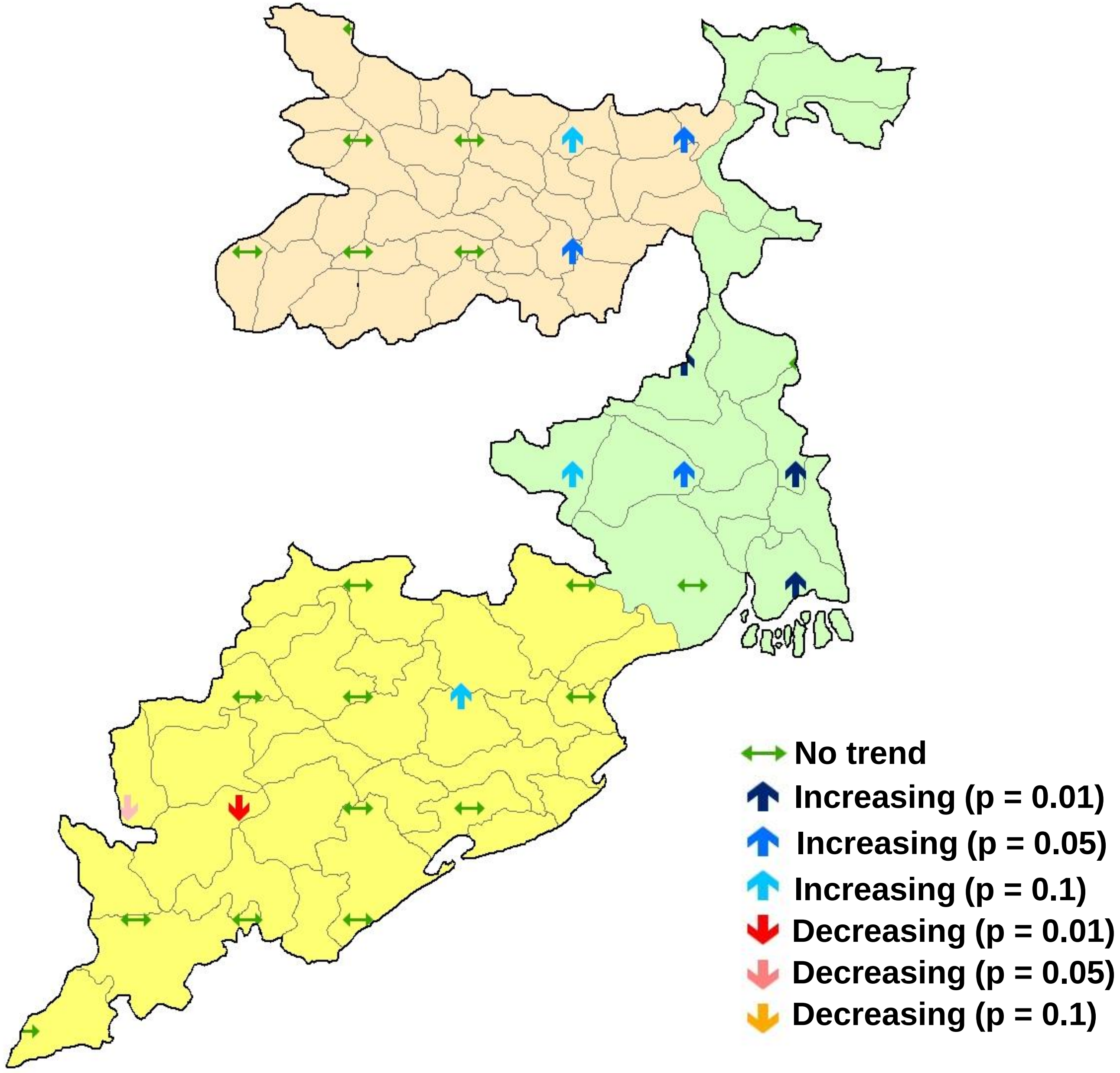
Submergence Tolerant Rice

IR 87439, IR 88228, IR 85086, Ciherang Sub1, Swarna Sub1, Savitri Sub1, Lalat, Pratikshya, Mahanadi, Swarna

Trend in annual rainfall over Eastern states of India (1951 – 2007)

- Eastern parts of Bihar has shown increasing tendency in annual rainfall where as no significant trend was noticed in other regions

- In Orissa, declining trend is noticed in western part and increasing trend in northeastern part. In the case of West Bengal, increasing tendency is seen in almost all regions except southeast where no significant trend was observed

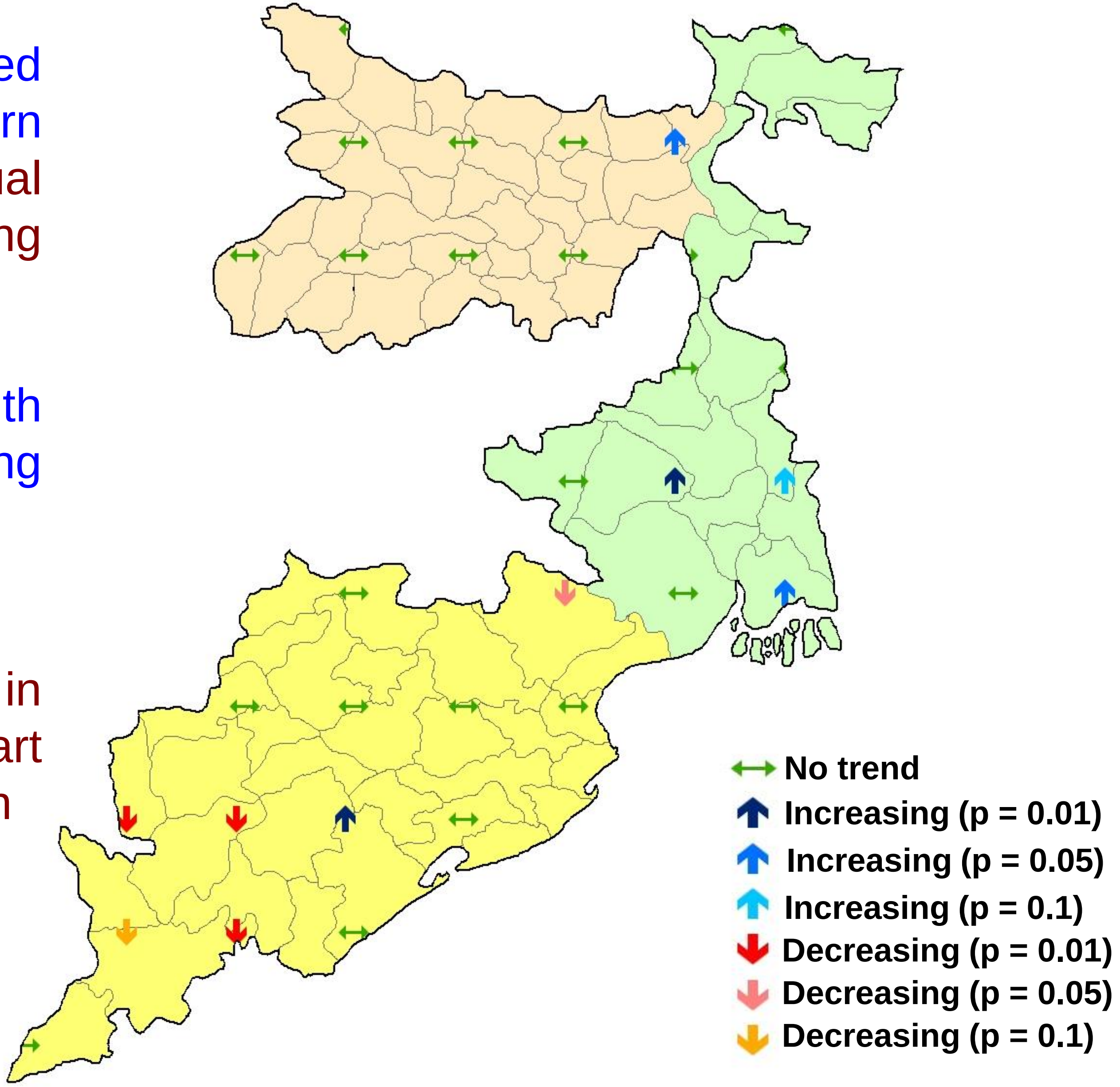


Trend in annual rainy days over Eastern states of India (1951 – 2007)

- Declining tendency was observed south western and north eastern parts of Orissa. At the same, annual rainy days is showing increasing trend in central part of Orissa

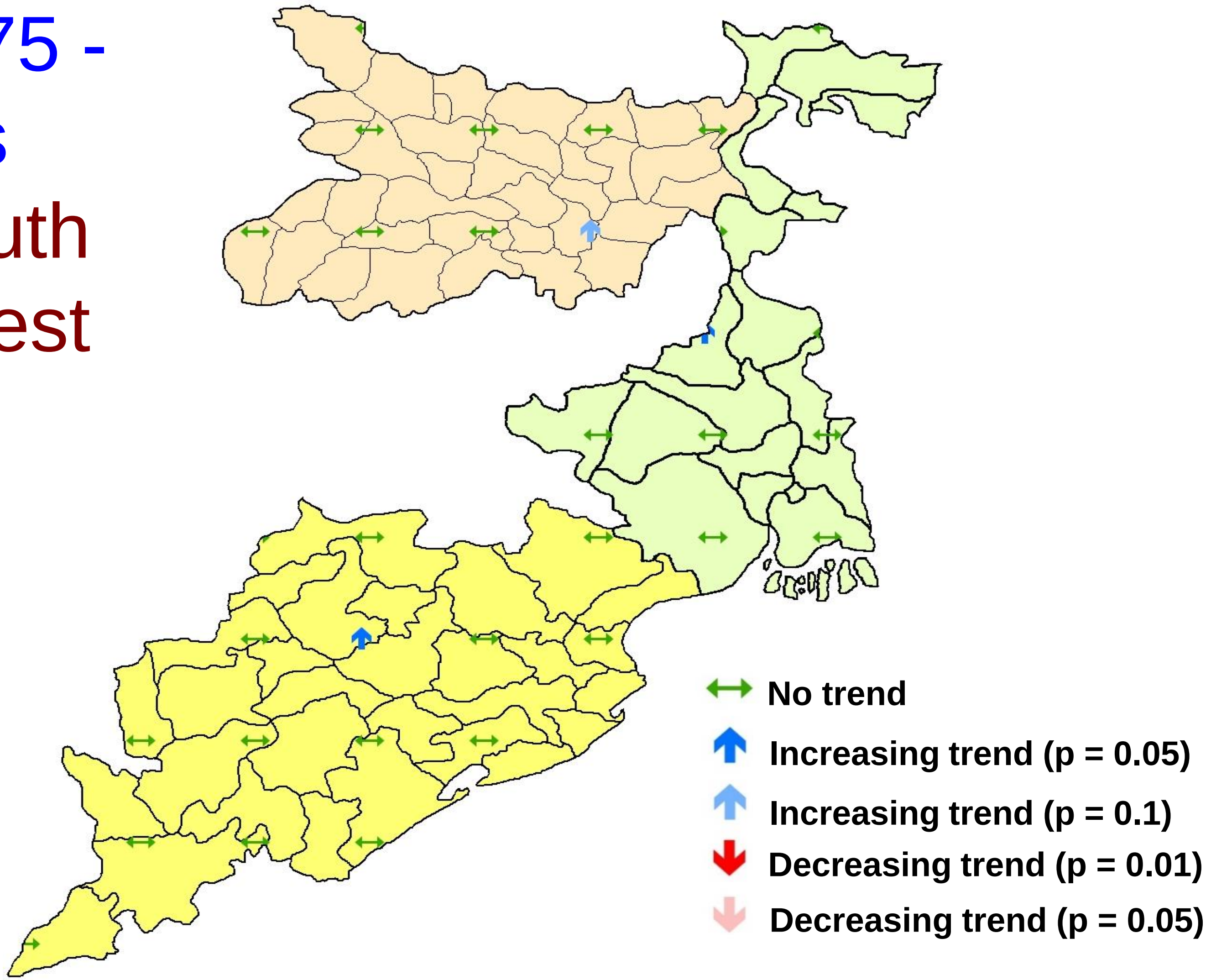
- In West Bengal, central and south eastern part showed increasing trend in annual rainy days.

- No significant trend is noticed in Bihar except north eastern part where increasing tendency is seen



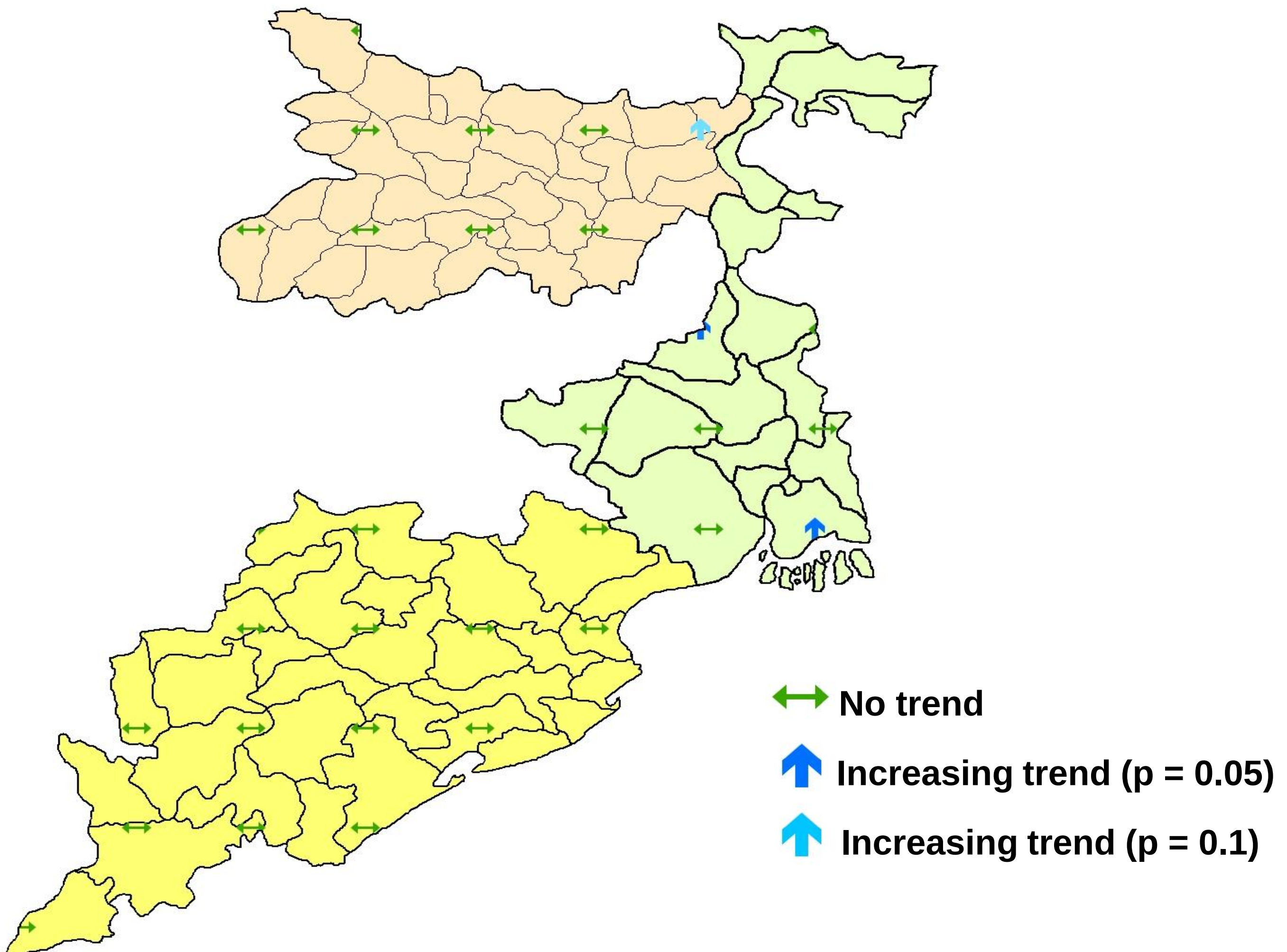
Trend in heavy rainfall (75 -100 mm / day) on annual basis over Eastern states of India

- Increasing trend on 75 - 100 mm / day events were observed in south east Bihar, central west Bengal and northern Orissa



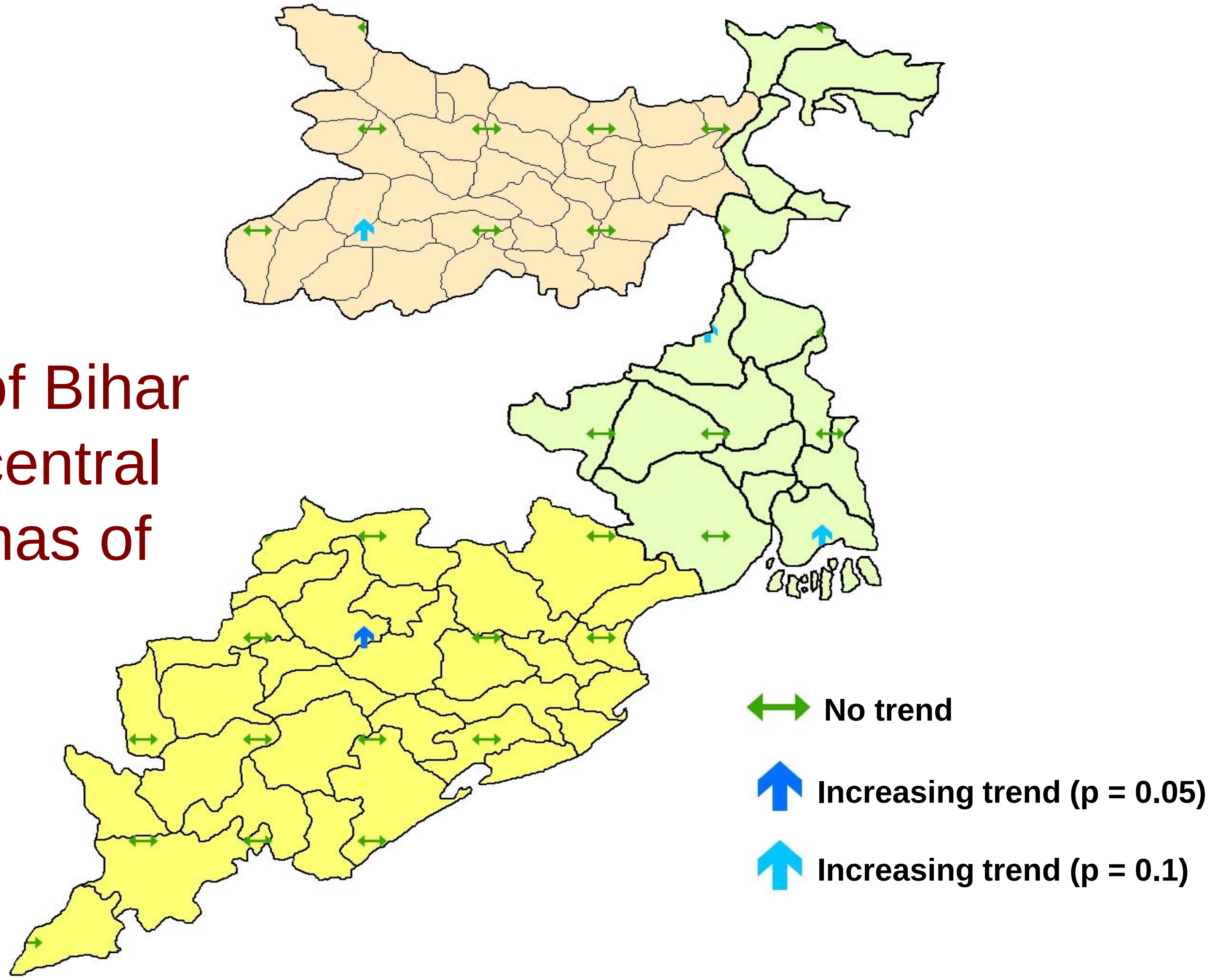
Trend in heavy rainfall (Above 100 mm / day) on annual basis over Eastern states of India

- Above 100 mm per day rainfall event, northeast Bihar, central West Bengal, South 24 Paraganas showed increasing trend. In Orissa no trend was found



Trend in heavy rainfall (75 - 100 mm / day) during Southwest monsoon over Eastern states of India

Increased tendency is noticed in southwest of Bihar ,Northern orissa and central and South 24 Paraganas of west Bengal

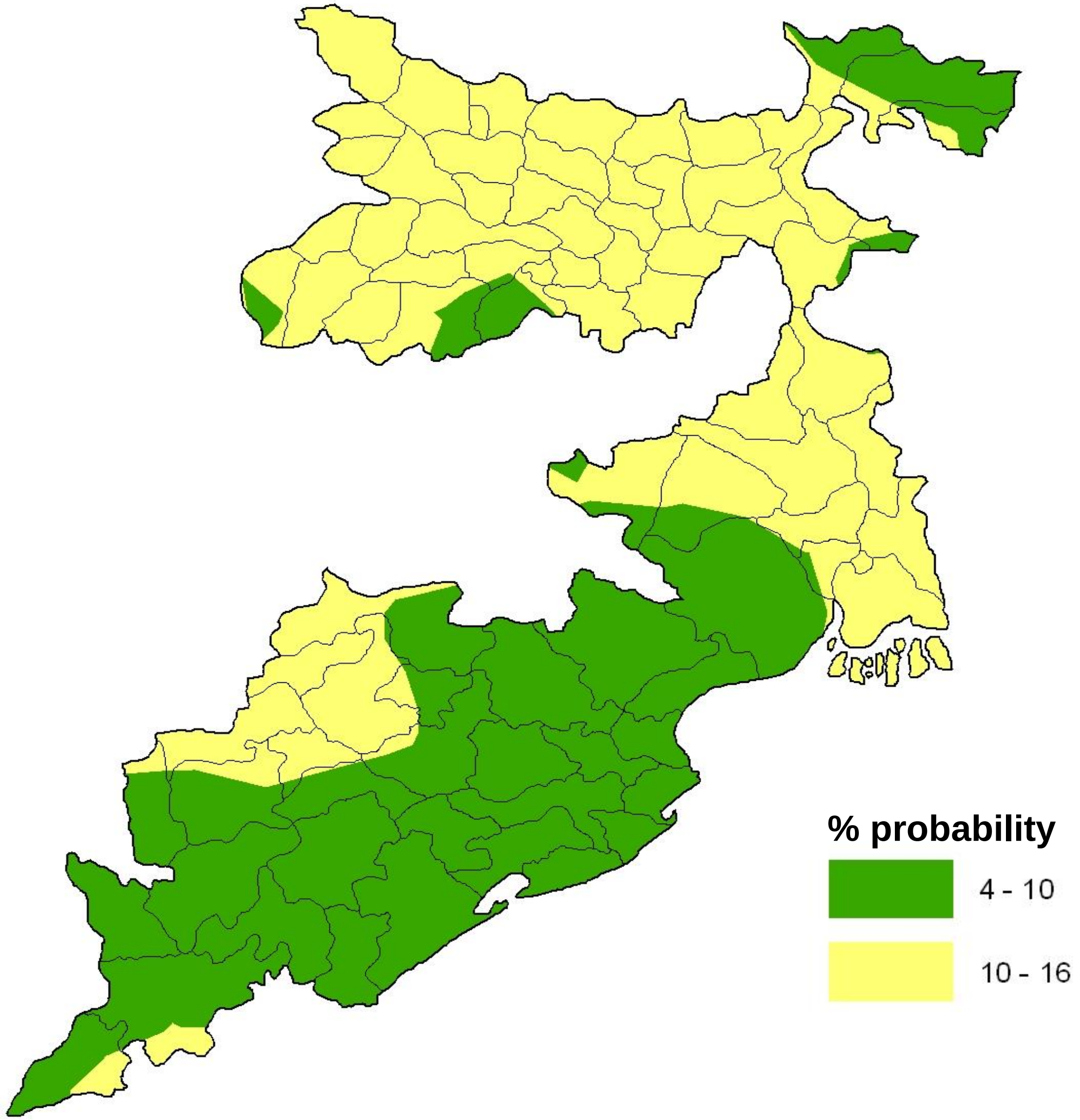


Moderate drought probability (%) over Eastern states of India (1901 – 2000)

- Moderate drought 4 -10 (%) probability over the orissa except northwest part of the orissa

- Moderate drought 10 -16 (%) probability distributed over major part of Bihar and West Bengal and NW Orissa

- Moderate drought 4 -10 (%) probability distributed over northern parts of West Bengal

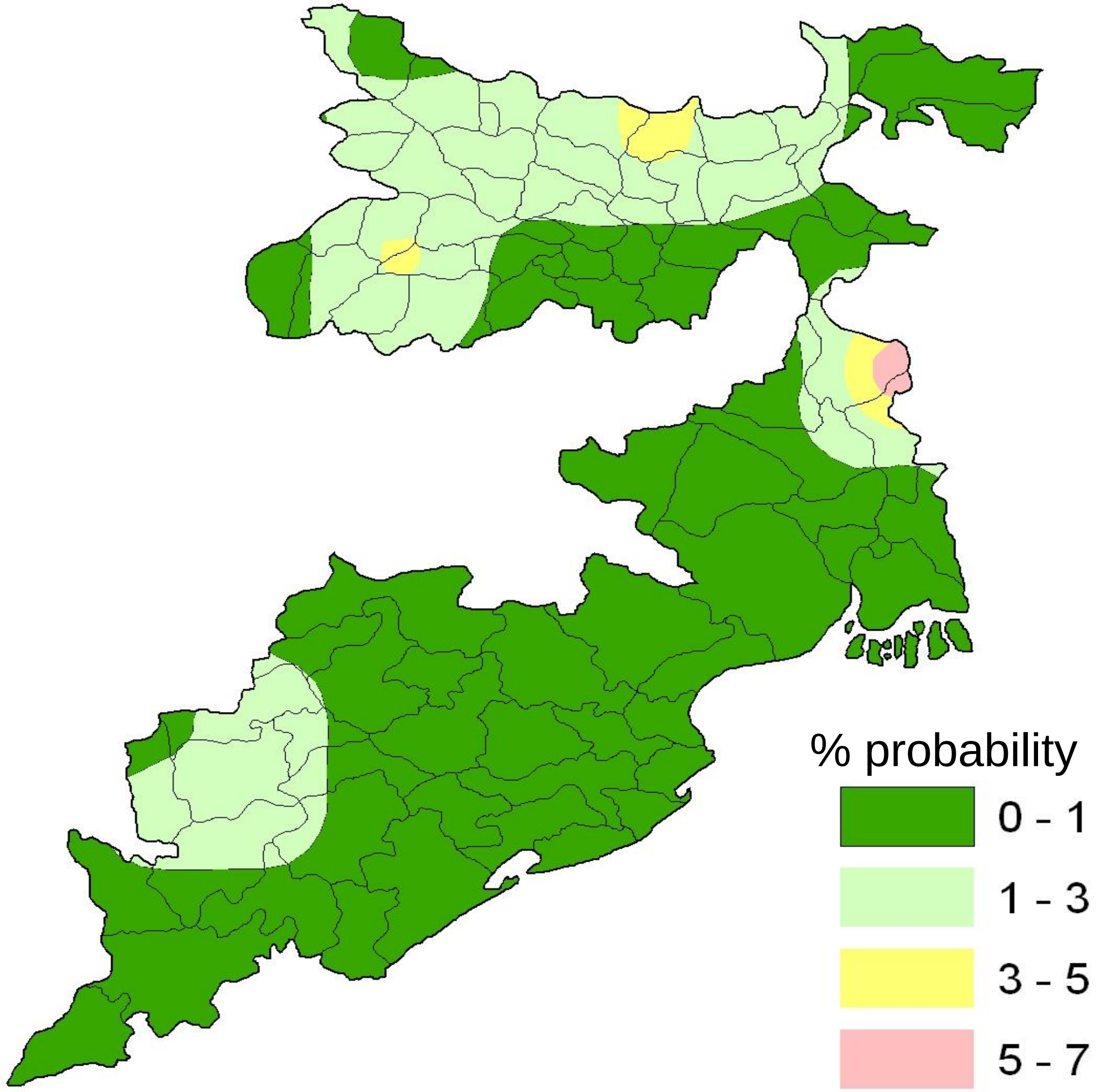


Severe drought probability (%) over Eastern states of India (1901 – 2000)

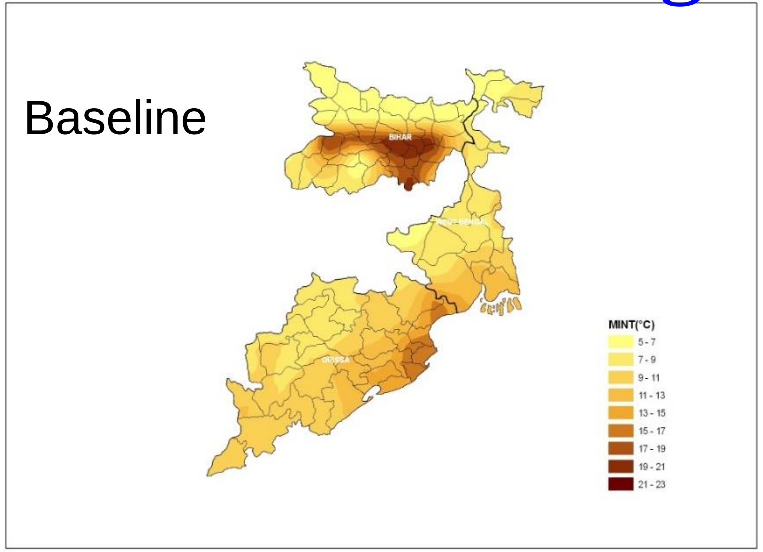
- Severe drought 1 (%) probability distributed over the orissa state except west part of the orissa and west Bengal except eastern part

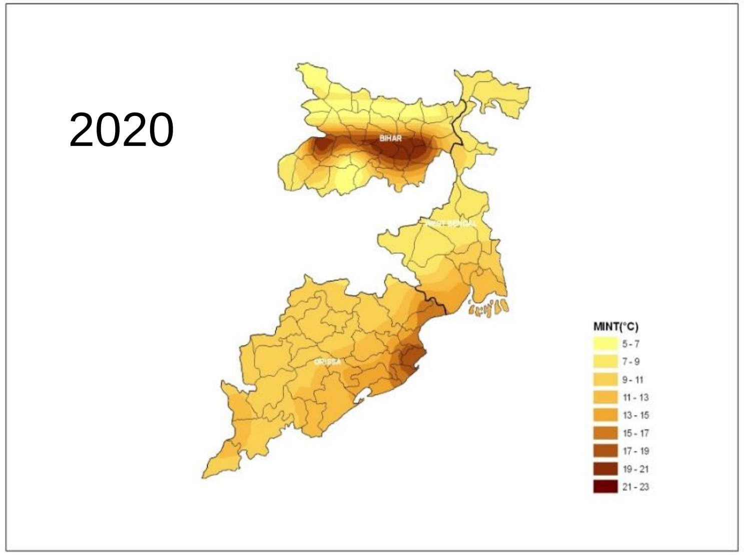
- Severe drought 1-3 (%) probability distributed west part of the orissa and major part of the Bihar state

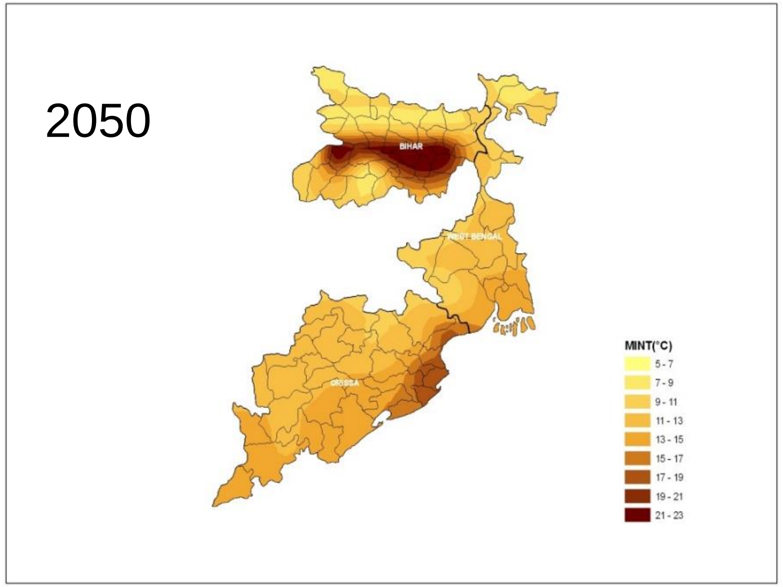
- Severe drought 3-7(%) probability distributed eastern part of the west Bengal



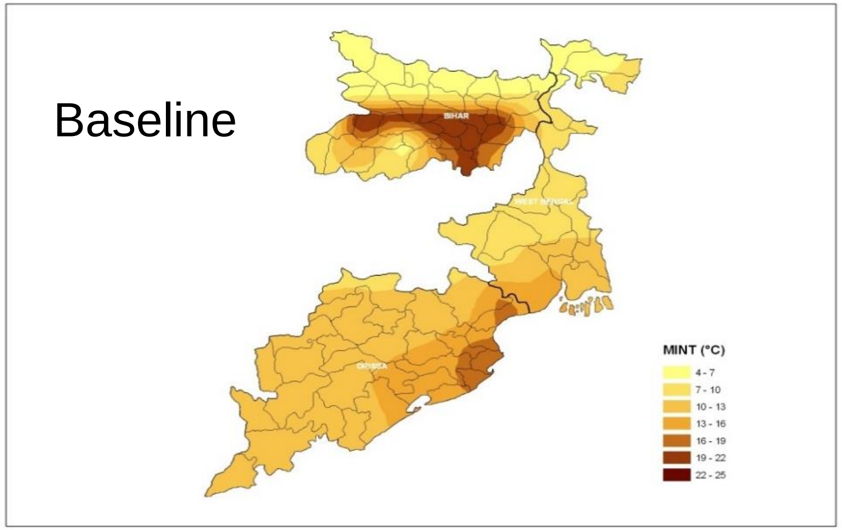
Projected minimum temperature distribution during December month

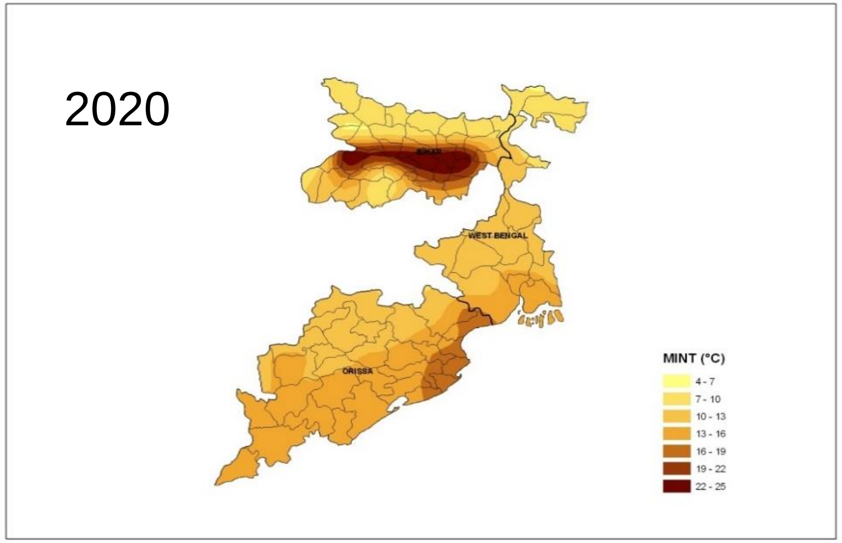


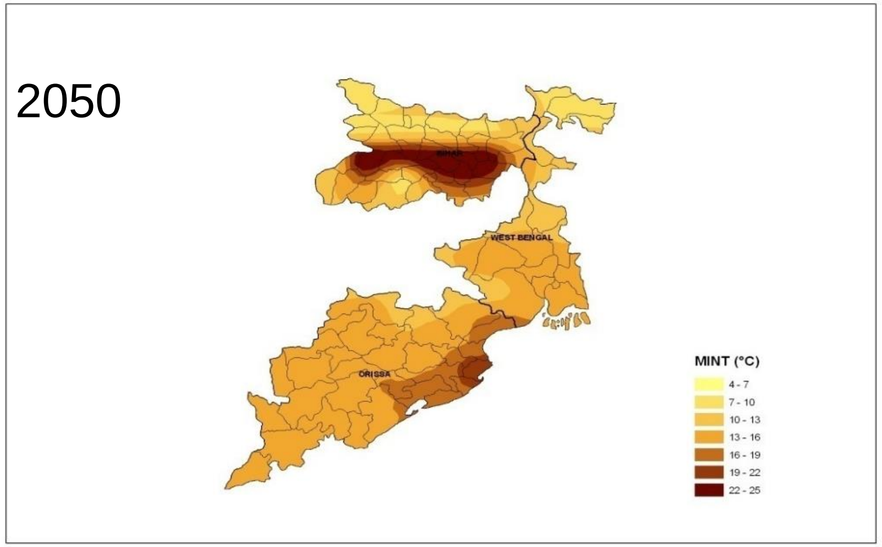




Projected minimum temperature distribution during January month

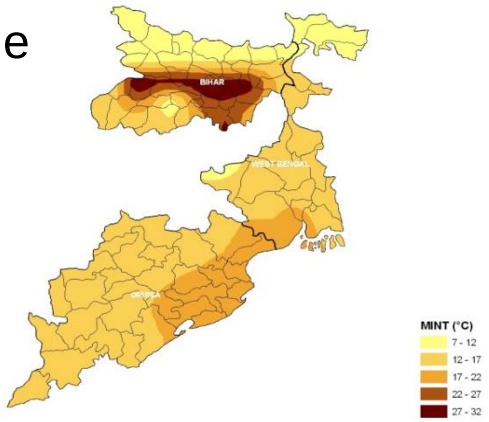




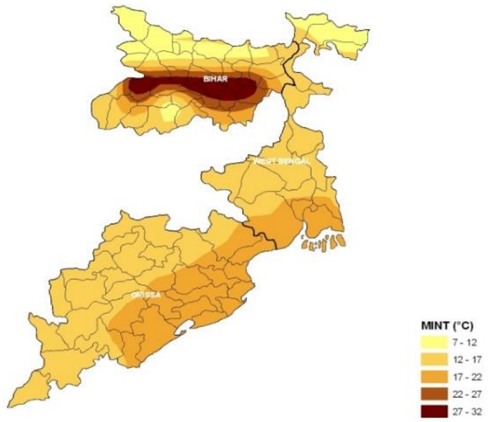


Projected minimum temperature distribution during February month

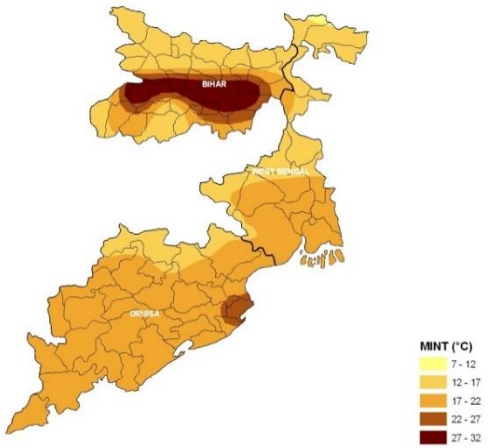
Baseline



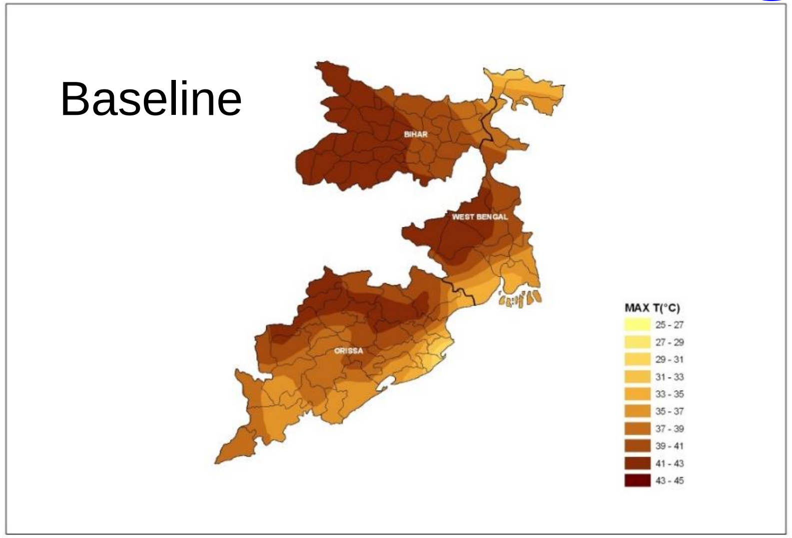
2020

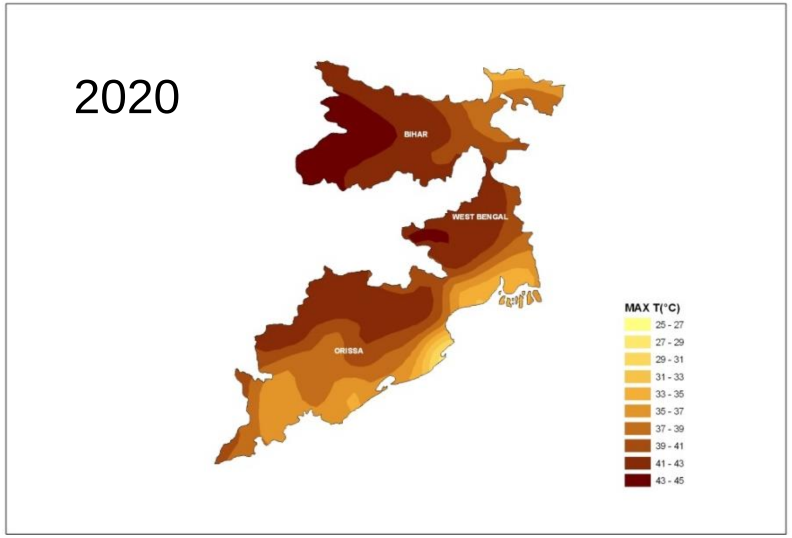


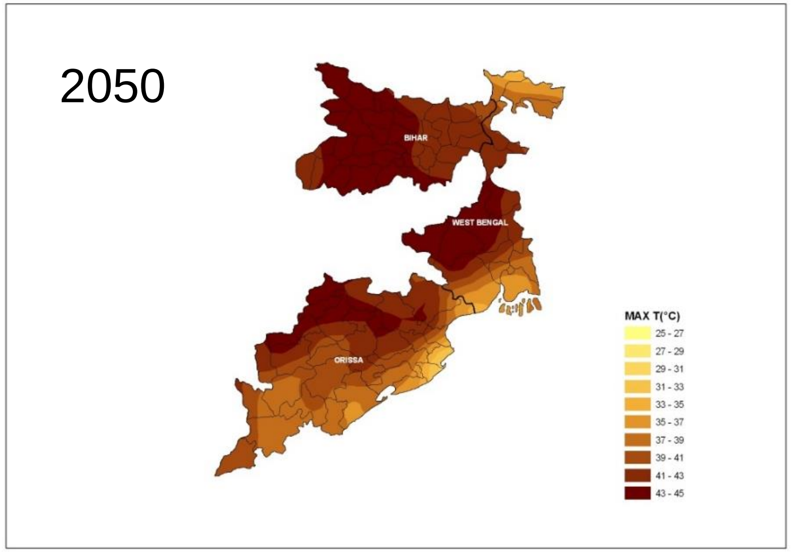
2050



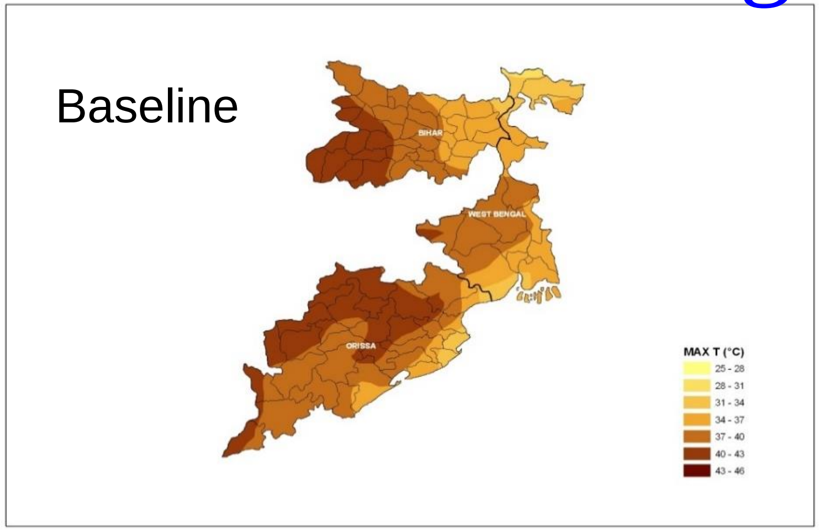
Projected maximum temperature distribution during April month

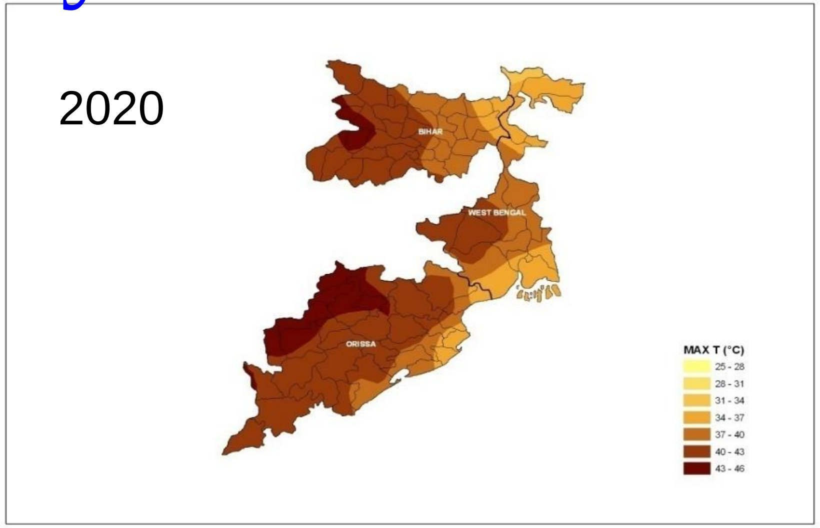


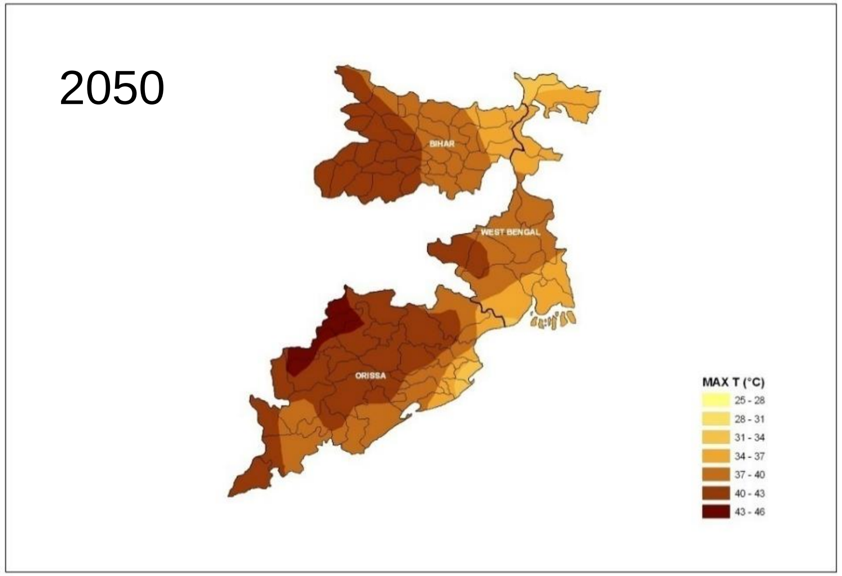




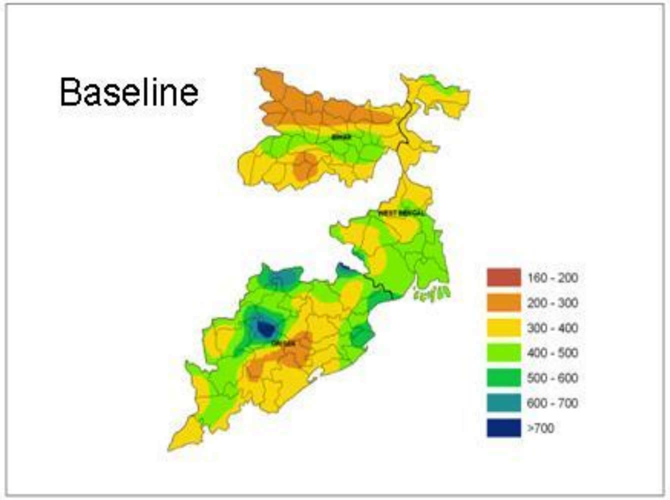
Projected maximum temperature distribution during May month

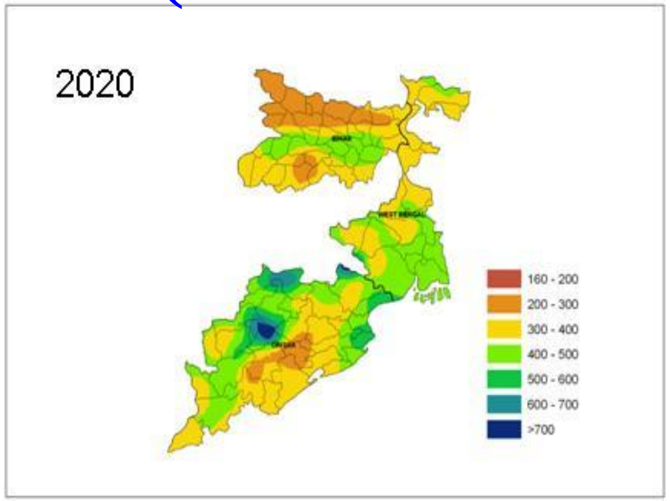


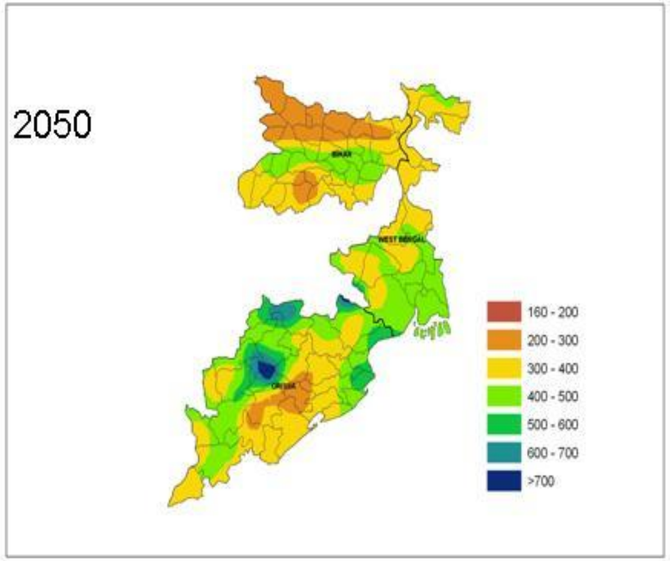




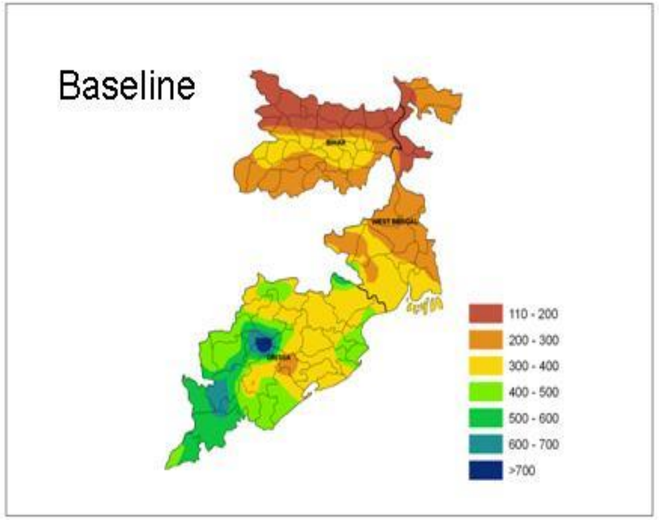
Spatial distribution of Rainfall over Orissa, West Bengal and Bihar for June Month (A2a Scenario)

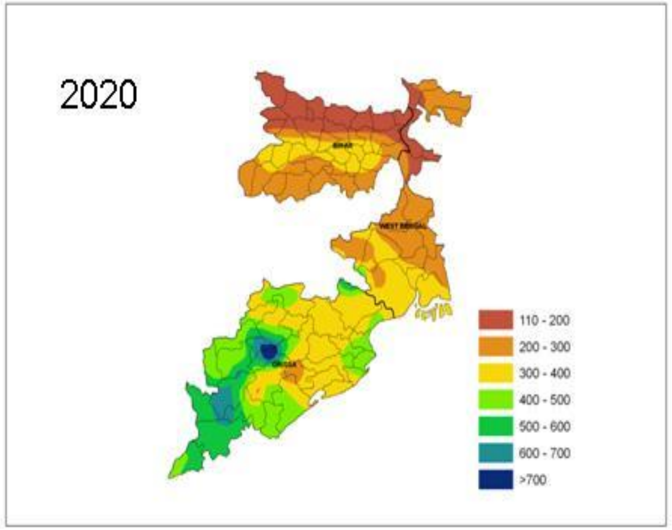


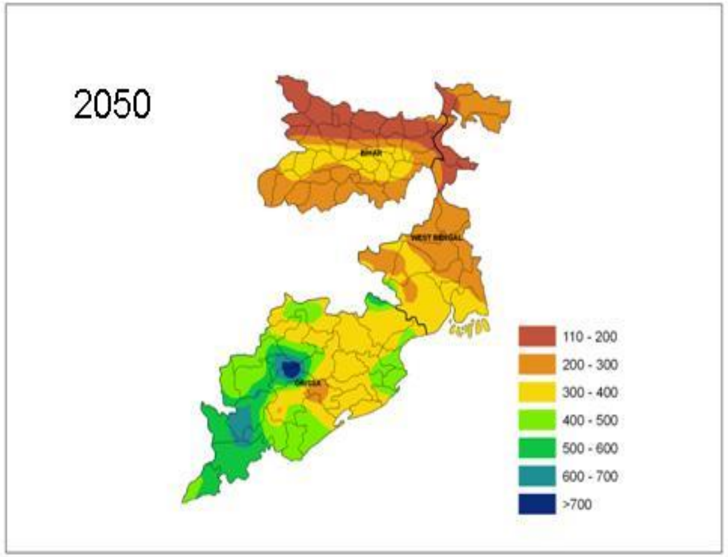




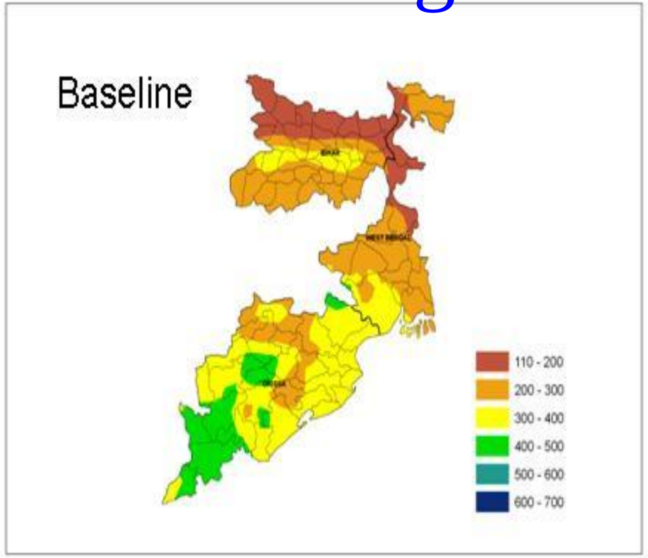
Spatial distribution of Rainfall over Orissa, West Bengal and Bihar for July Month (A2a Scenario)

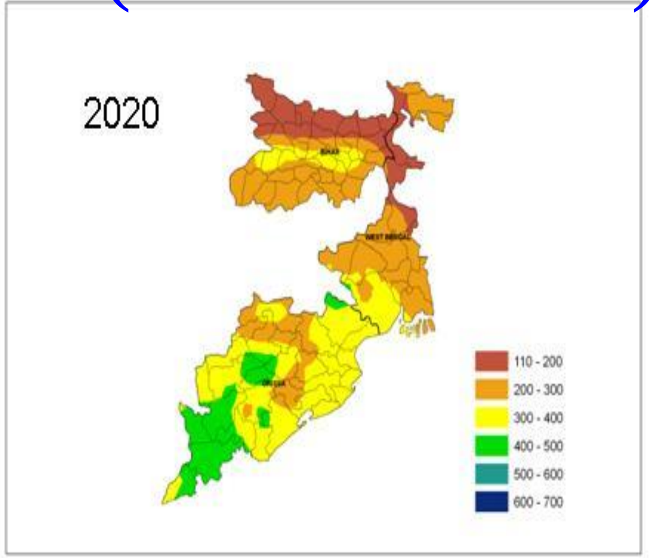


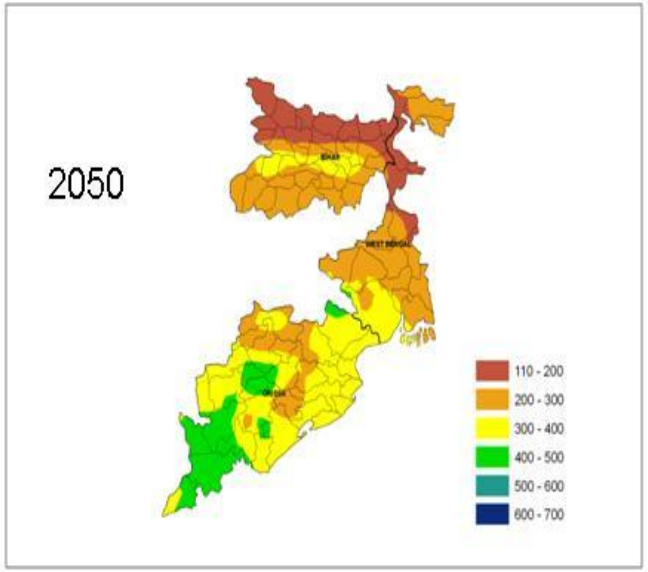




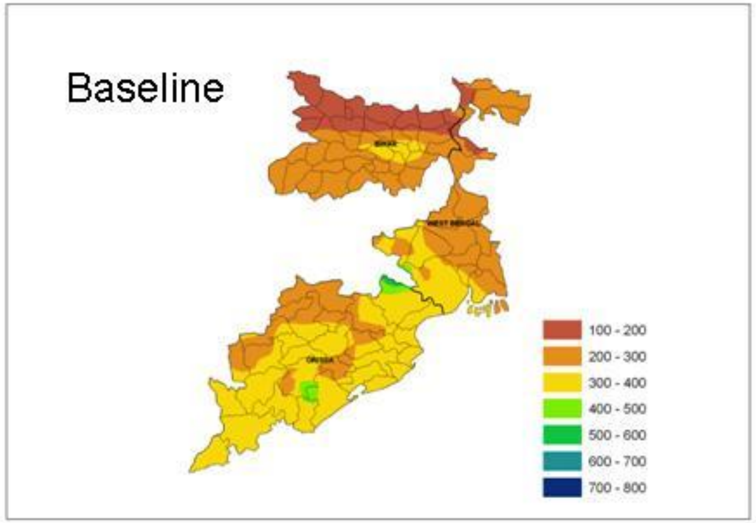
Spatial distribution of Rainfall over Orissa, West Bengal and Bihar for August Month (A2a Scenario)

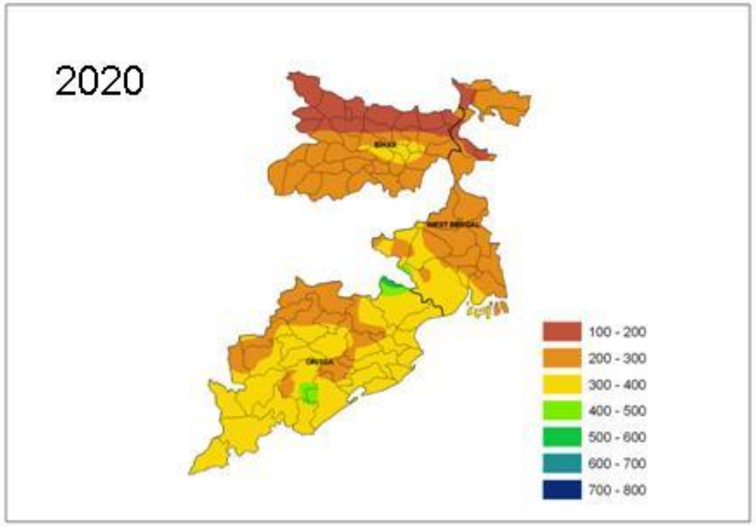


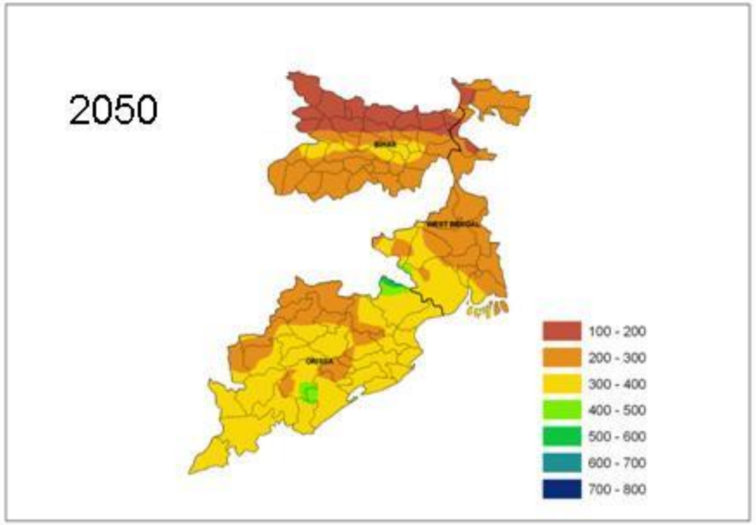




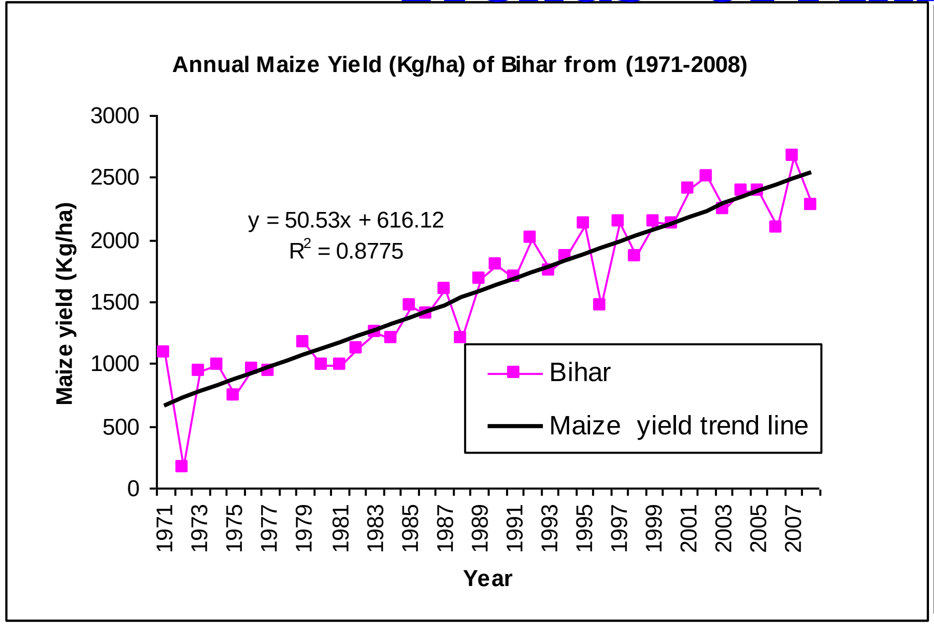
Spatial distribution of Rainfall over Orissa, West Bengal and Bihar for September Month (A2a Scenario)

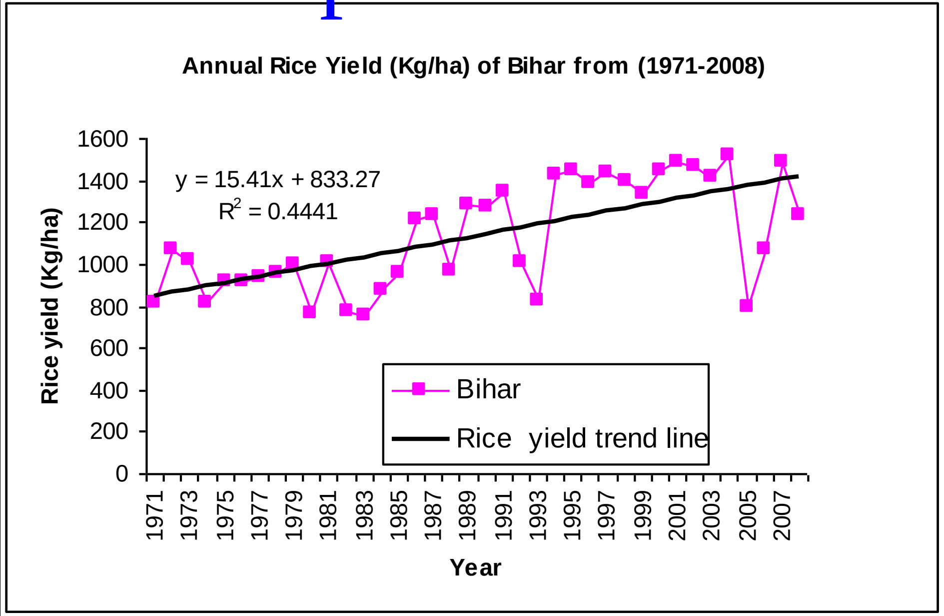


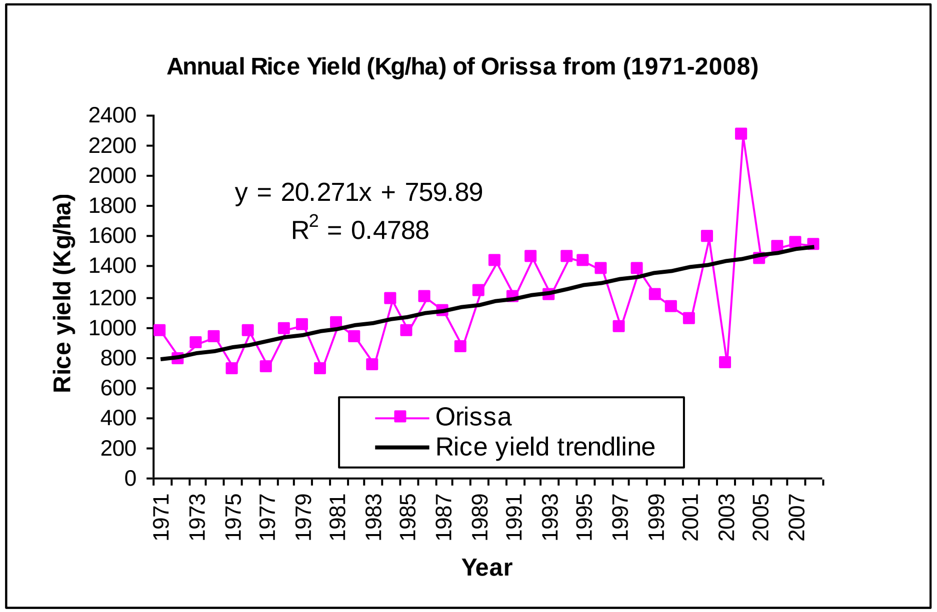


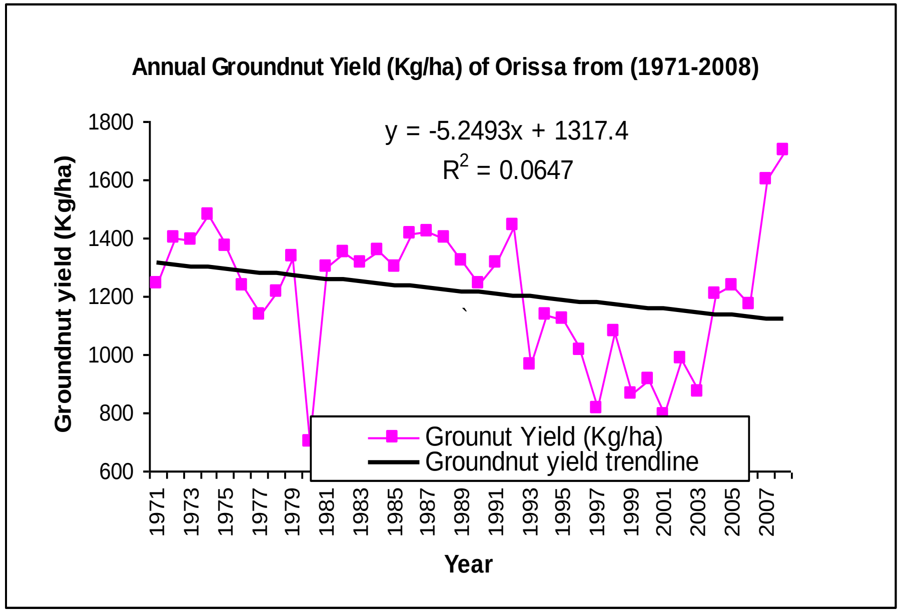


Trends of Annual Crop Yield

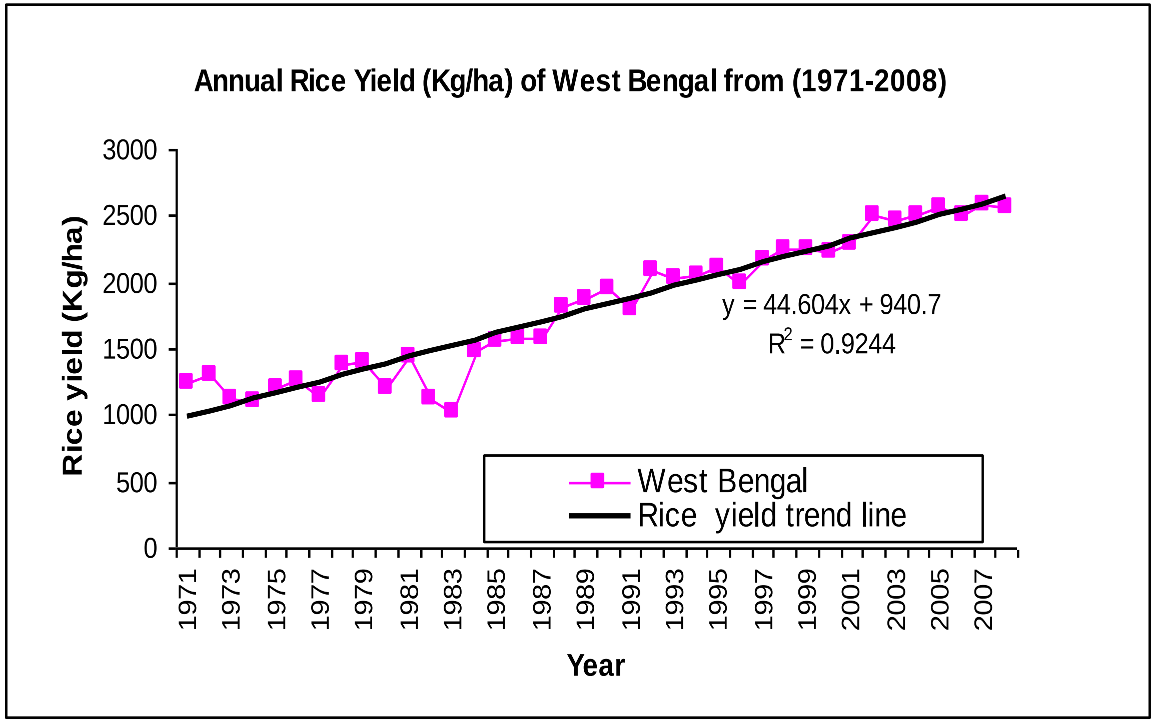


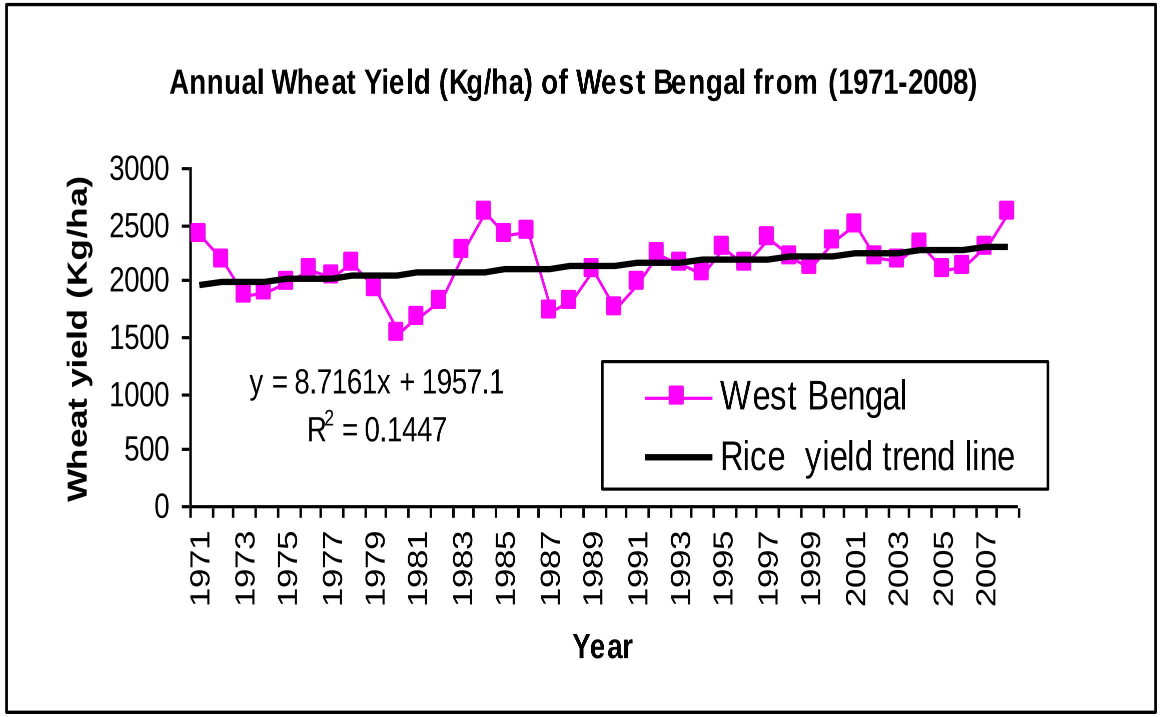


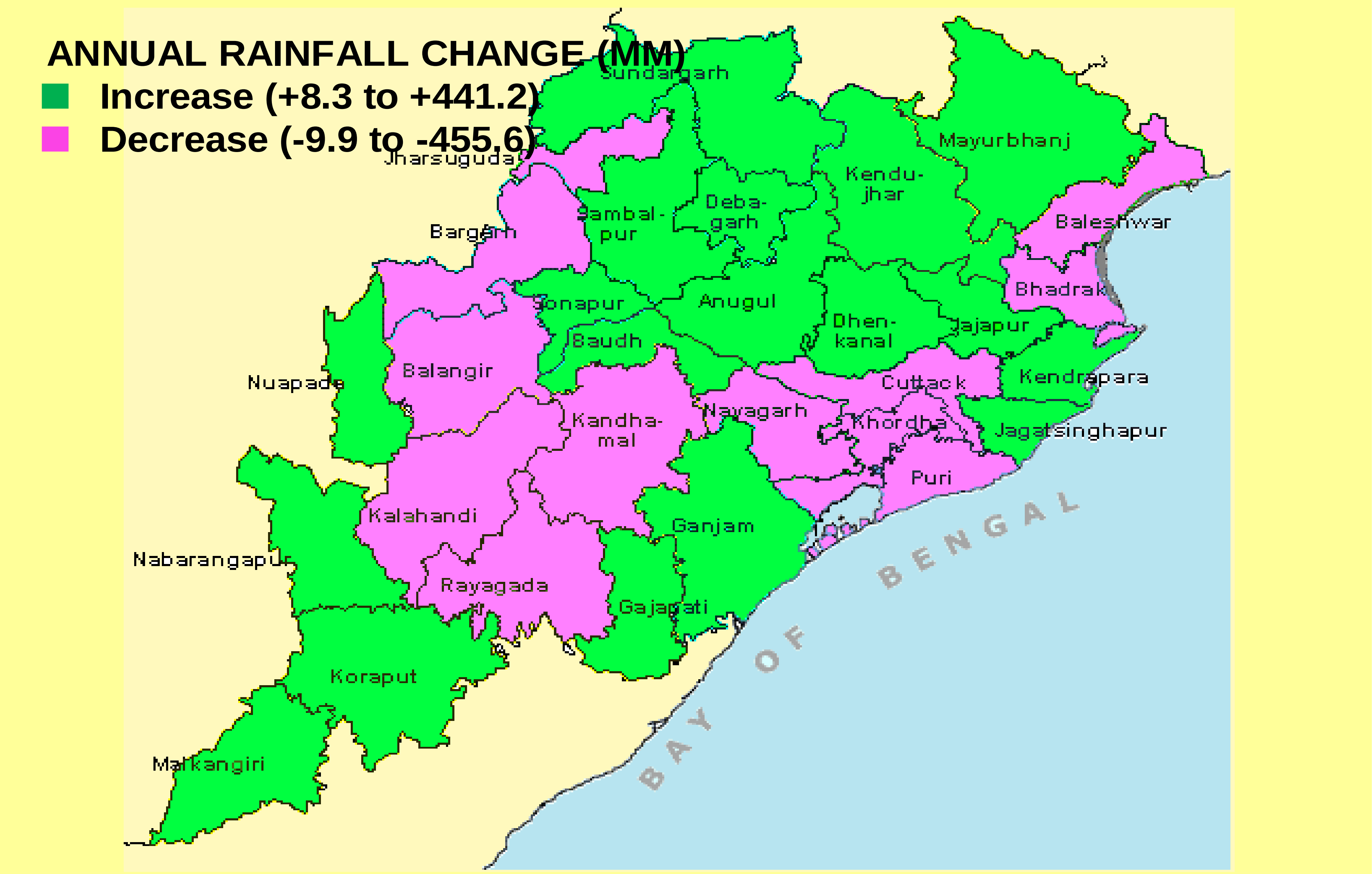




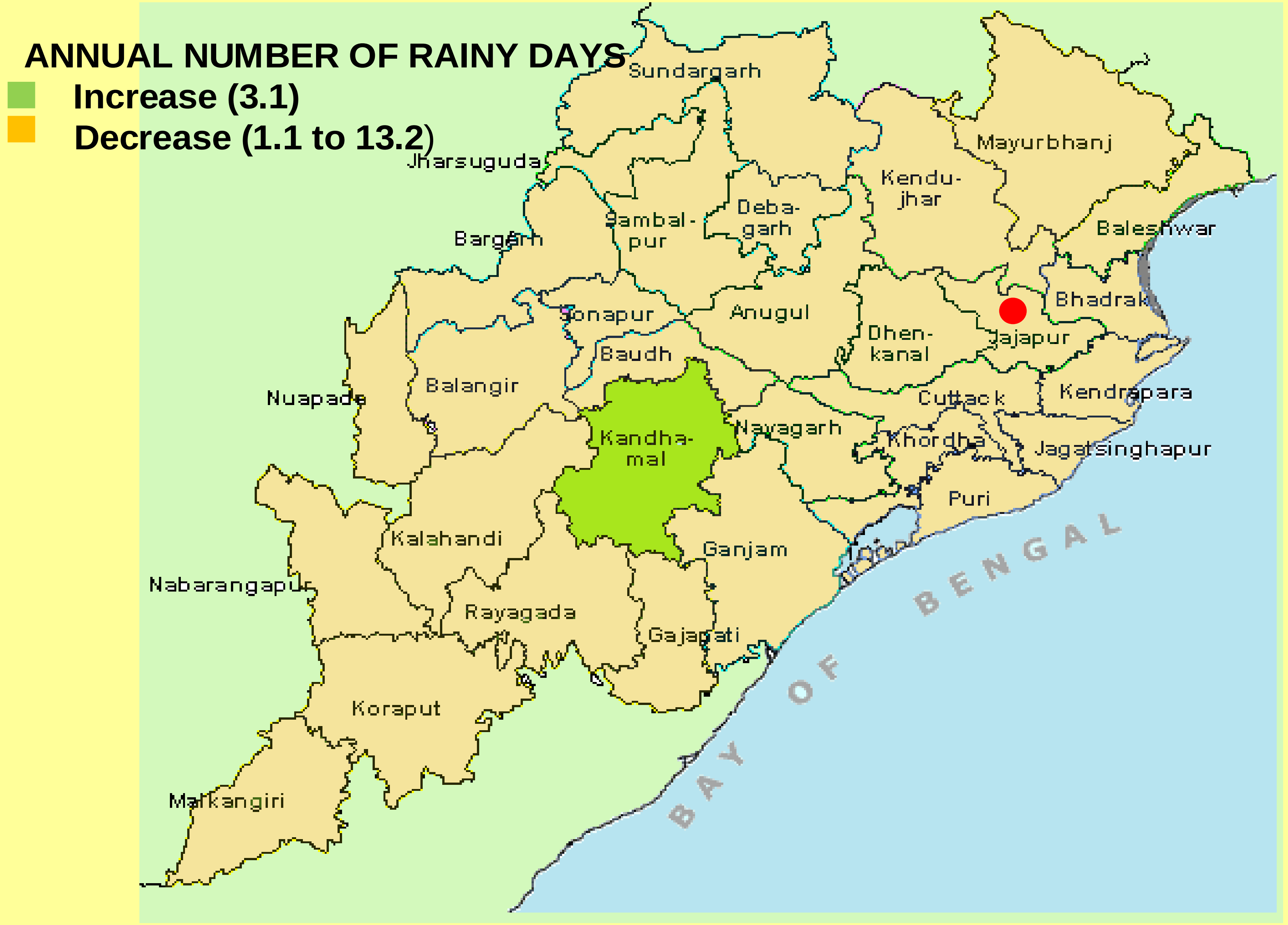
Trends of Annual Crop Yield



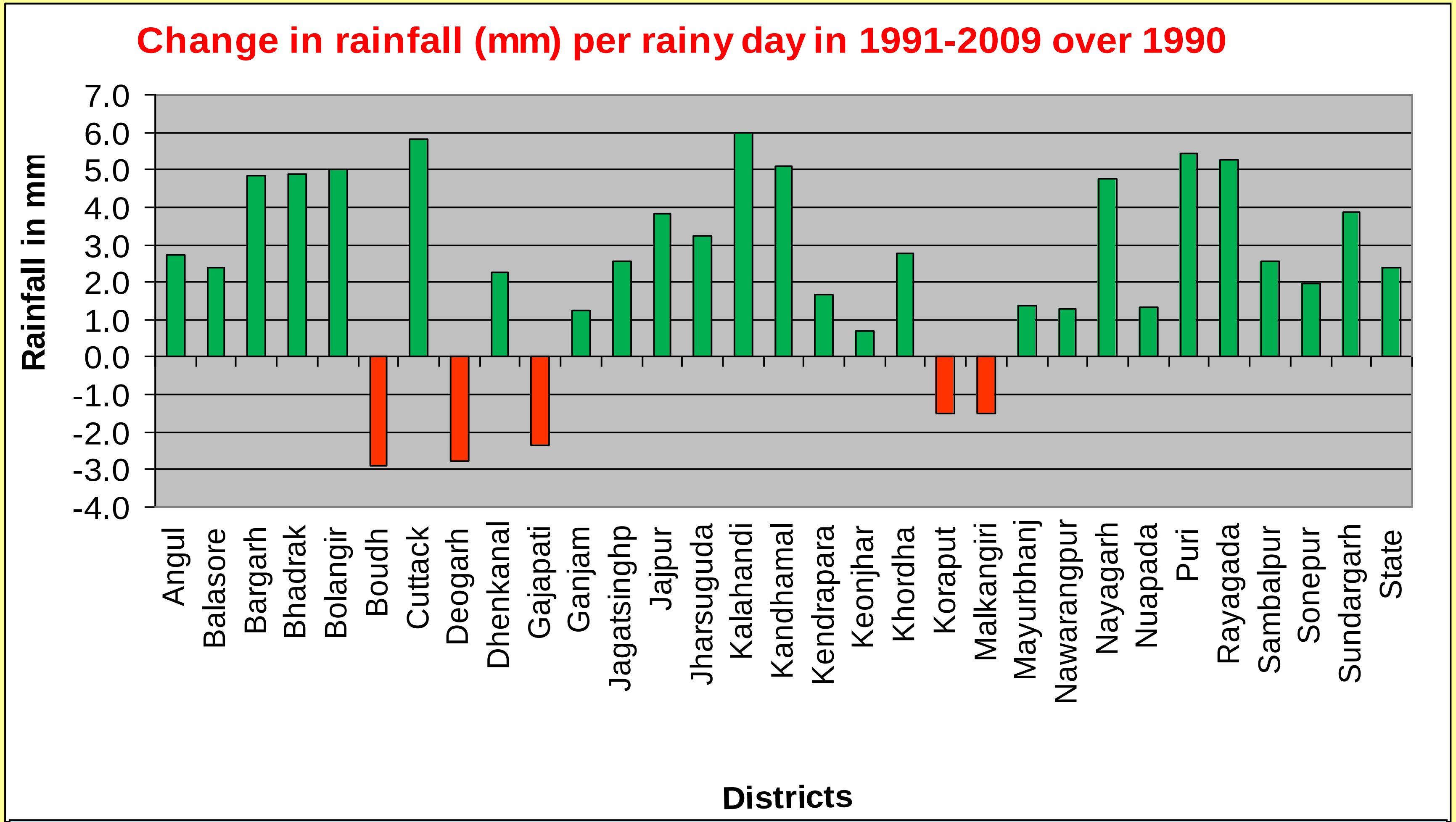




CHANGE IN ANNUAL RAINFALL (MM) IN 1991-2009 OVER 1990

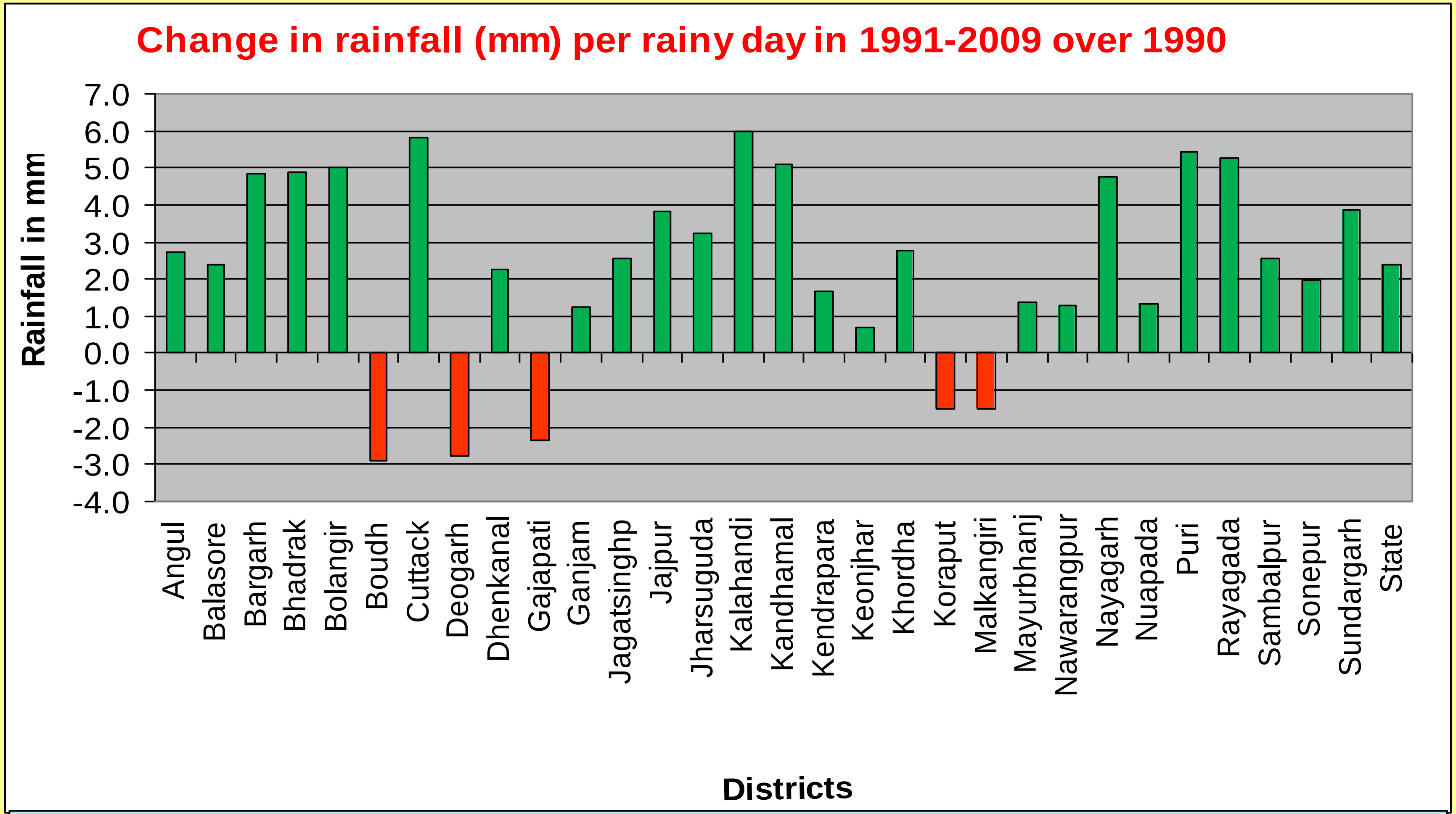


CHANGE IN ANNUAL NUMBER OF RAINY DAYS DURING 1991-2009 OVER 1990



Decreasing both no. of rainy days and rainfall intensity, mostly in south interior, is significant for agriculture:

- Operations requiring minimum rainfall amount in a period. e.g. Transplanting/ beushaning of rice (50 mm in a day) affected in 2002 and 2010

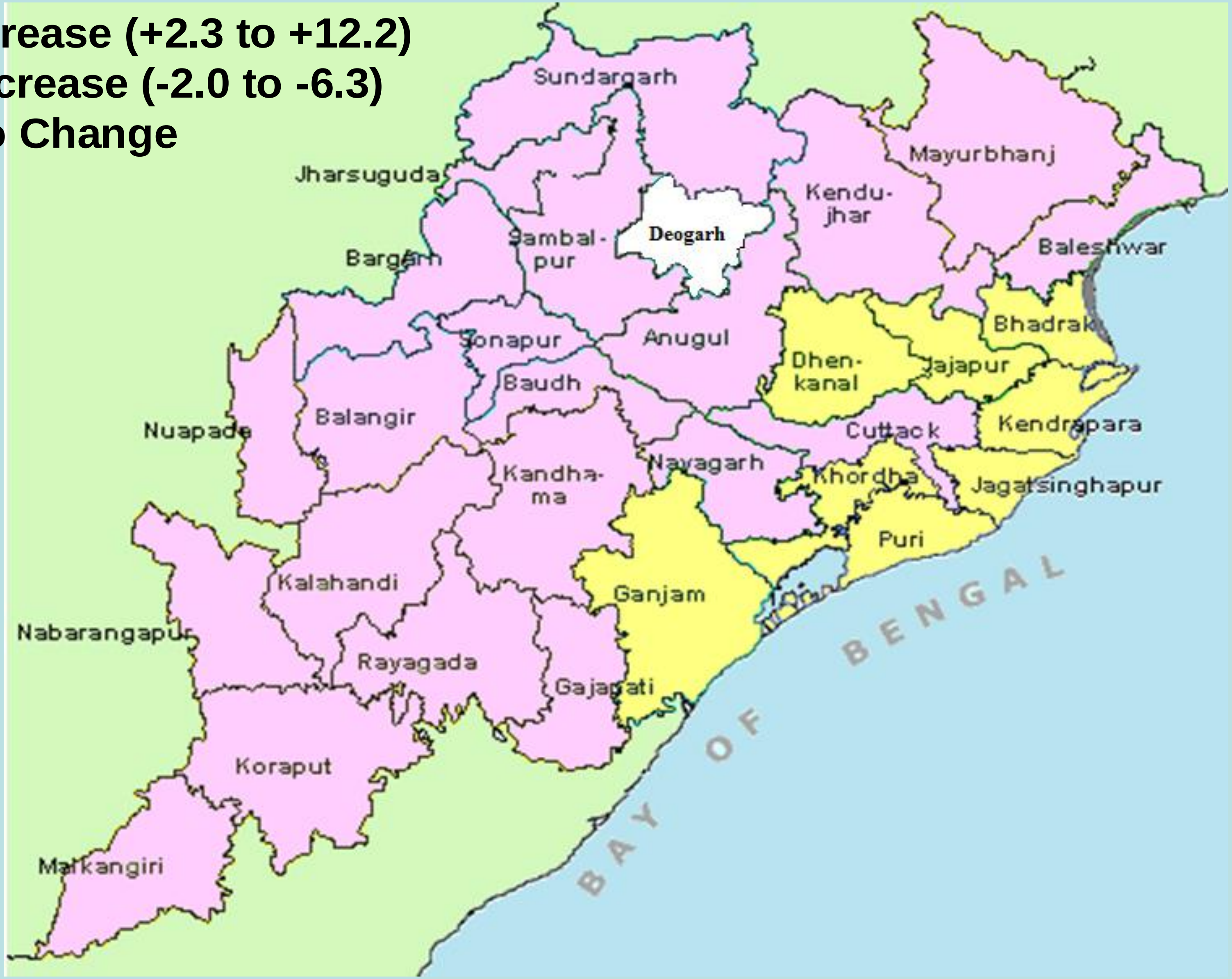


Decreasing both no. of rainy days and rainfall intensity, mostly in south interior, is significant for agriculture:

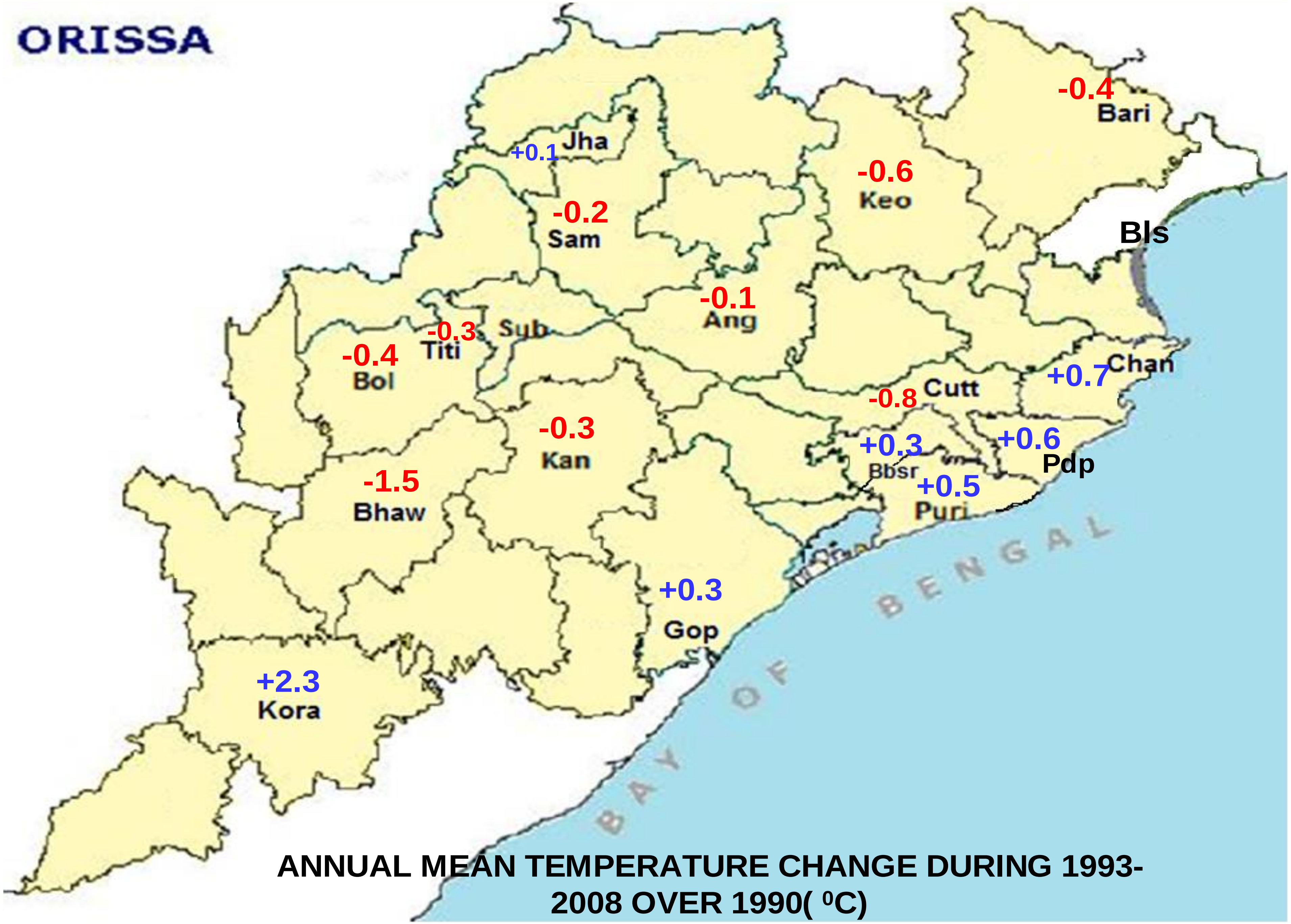
•Operations requiring minimum rainfall amount in a period. e.g. Transplanting/ beushaning of rice (50 mm in a day) affected in 2002 and 2010

VERY HEAVY RAINFALL DAYS

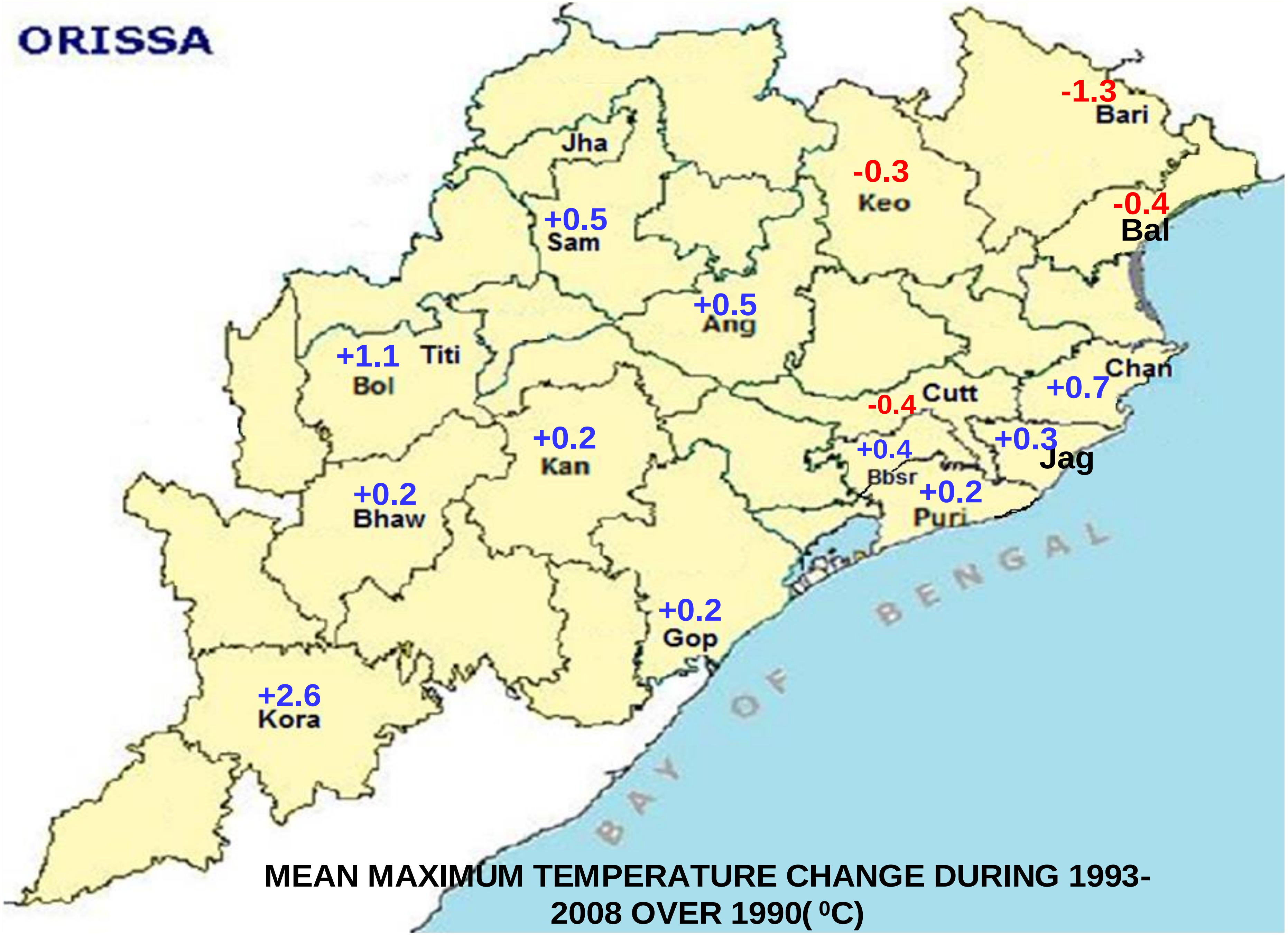
- Increase (+2.3 to +12.2)
- Decrease (-2.0 to -6.3)
- No Change



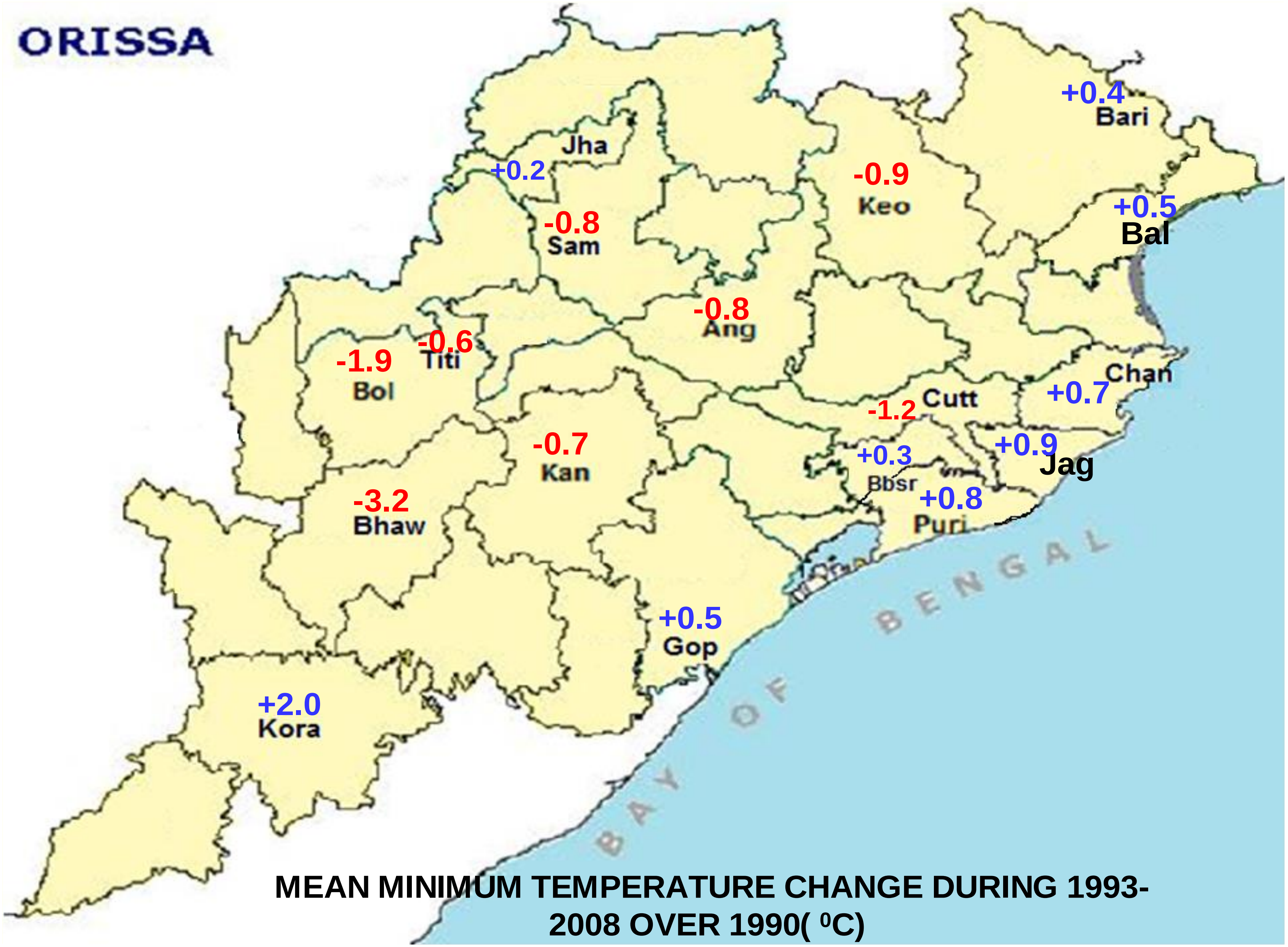
DISTRICT WISE CHANGE IN VERY HEAVY RAINFALL (>125MM) DAYS IN A YEAR DURING 2005-09 OVER 1995-1999



ANNUAL MEAN TEMPERATURE CHANGE DURING 1993-2008 OVER 1990(^{0}C)



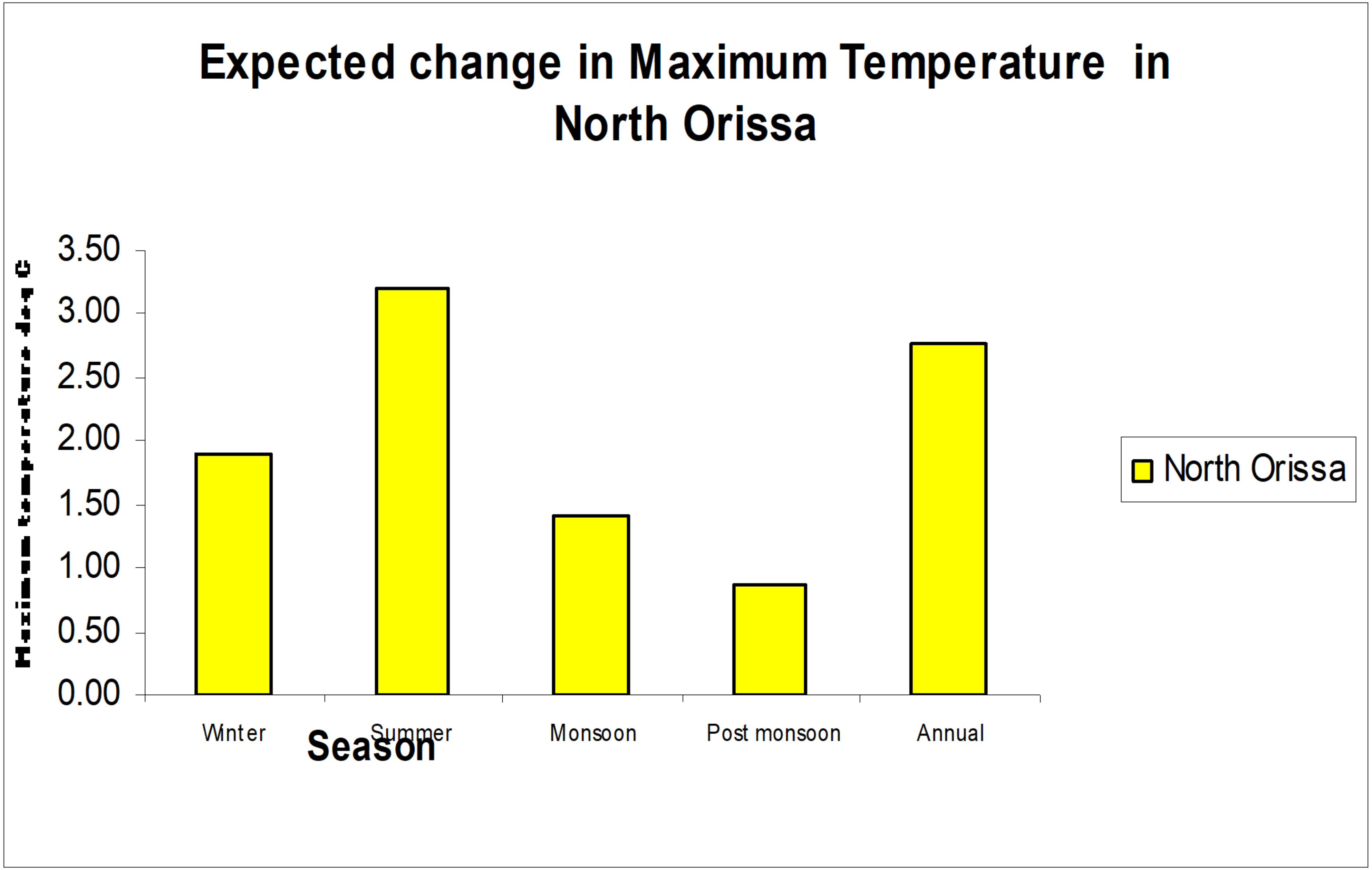
MEAN MAXIMUM TEMPERATURE CHANGE DURING 1993-2008 OVER 1990(^{0}C)

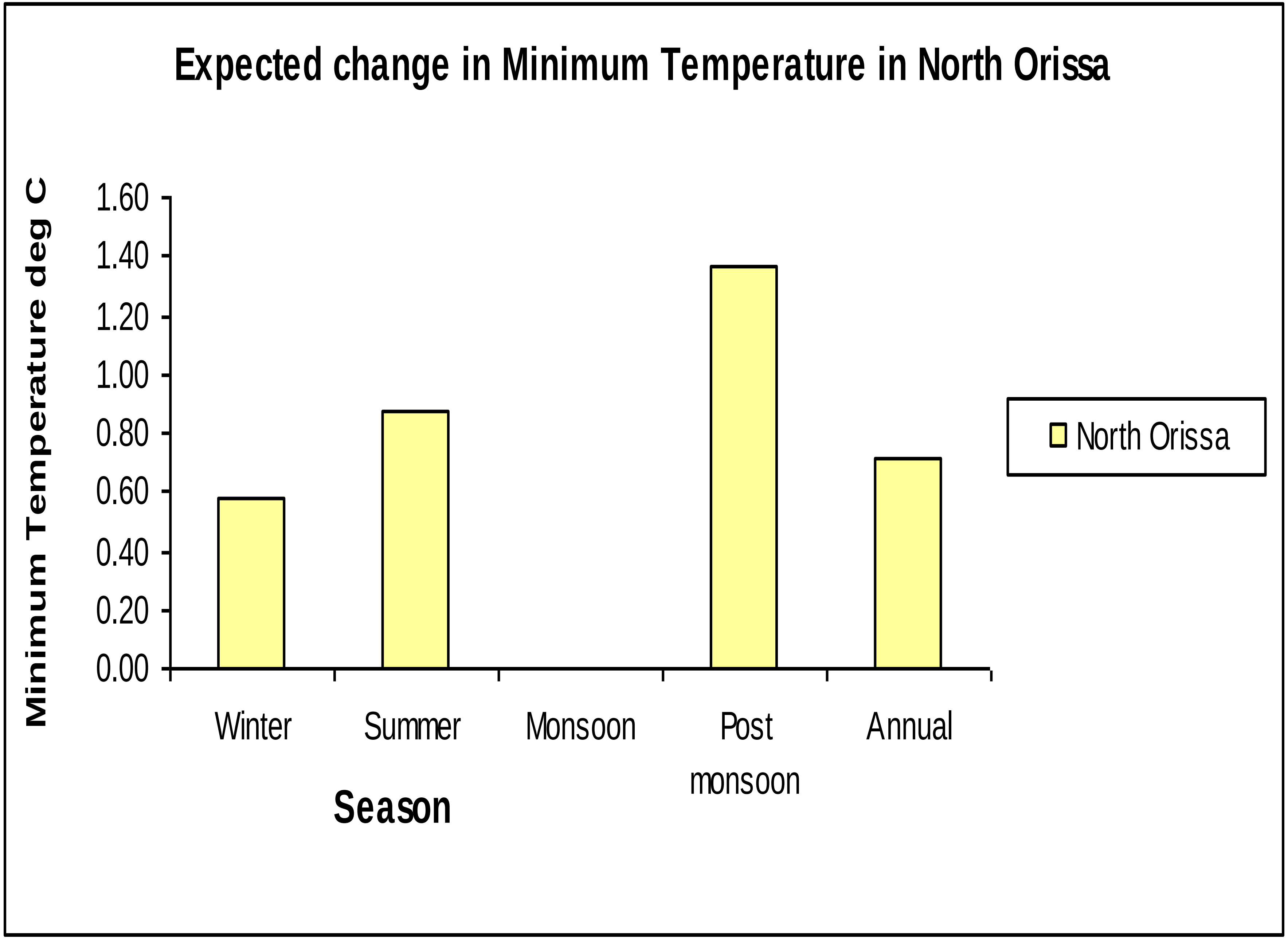


MEAN MINIMUM TEMPERATURE CHANGE DURING 1993-2008 OVER 1990(^{0}C)

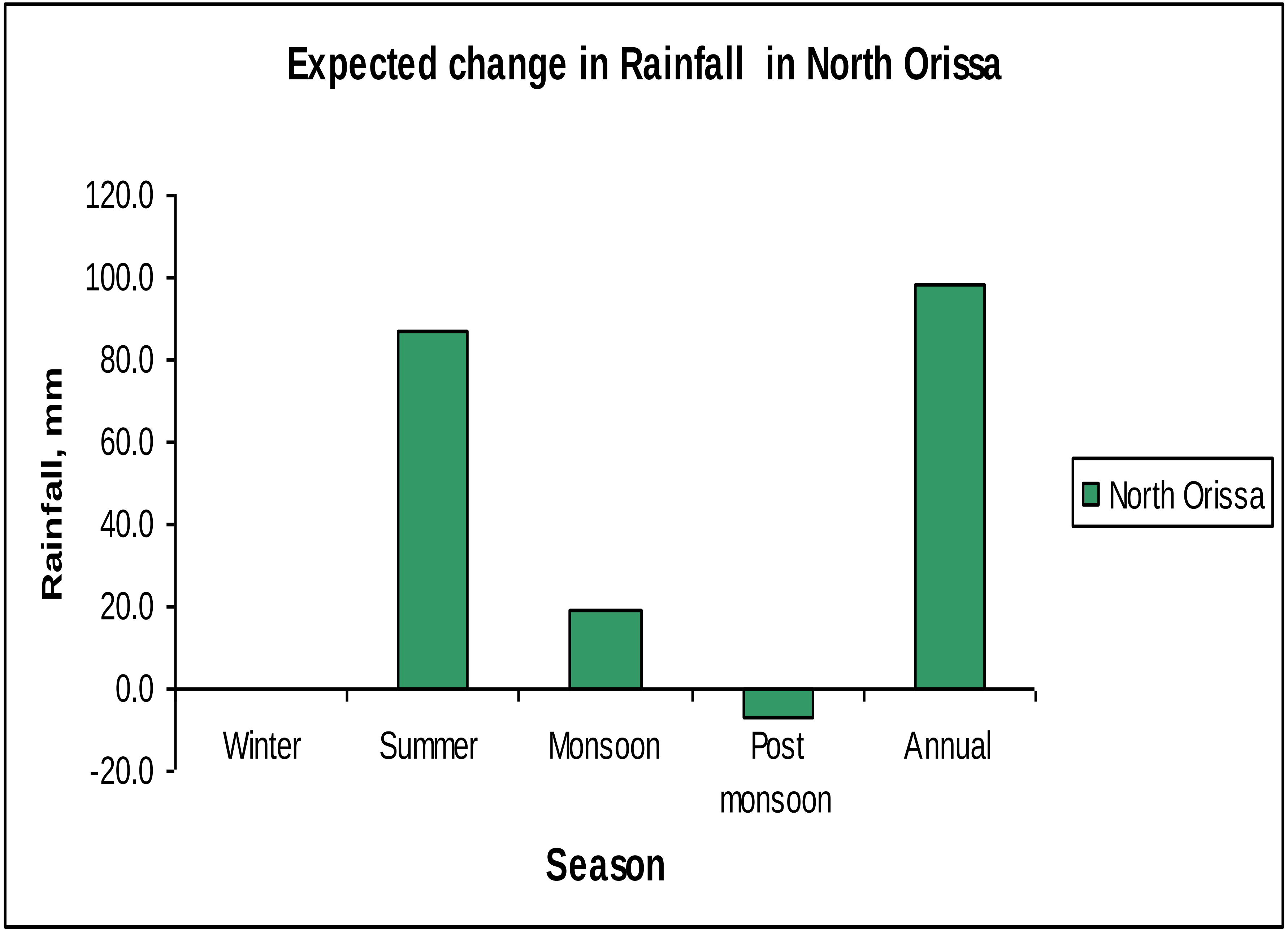
Projected change in mean seasonal Tmax (^oC) in North Orissa districts in 2020 over 1990

Districts	Winter	Summer	Monsoon	Post Monsoon	Annual
Angul	**3.28**	**1.41**	**0.85**	**2.66**	**1.90**
Balasore	**3.30**	**1.43**	**0.89**	**2.83**	**1.95**
Mayurbhanj	**3.00**	**1.41**	**0.89**	**2.80**	**1.87**
Chandabali	**3.25**	**1.42**	**0.87**	**2.84**	**1.93**
Cuttack	**3.63**	**1.48**	**0.88**	**2.96**	**2.07**
Jharsuguda	**2.87**	**1.40**	**0.87**	**2.56**	**1.79**
Keonjhar	**2.81**	**1.32**	**0.82**	**2.47**	**1.72**
Paradeep	**3.68**	**1.49**	**0.90**	**3.07**	**2.10**
Sambalpur	**2.97**	**1.38**	**0.88**	**2.65**	**1.82**
North Orissa	**3.20**	**1.42**	**0.87**	**2.76**	**1.90**


Expected change in Maximum Temperature in North Orissa
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Winter
Summer
Monsoon
Post monsoon
Annual
Season
North Orissa



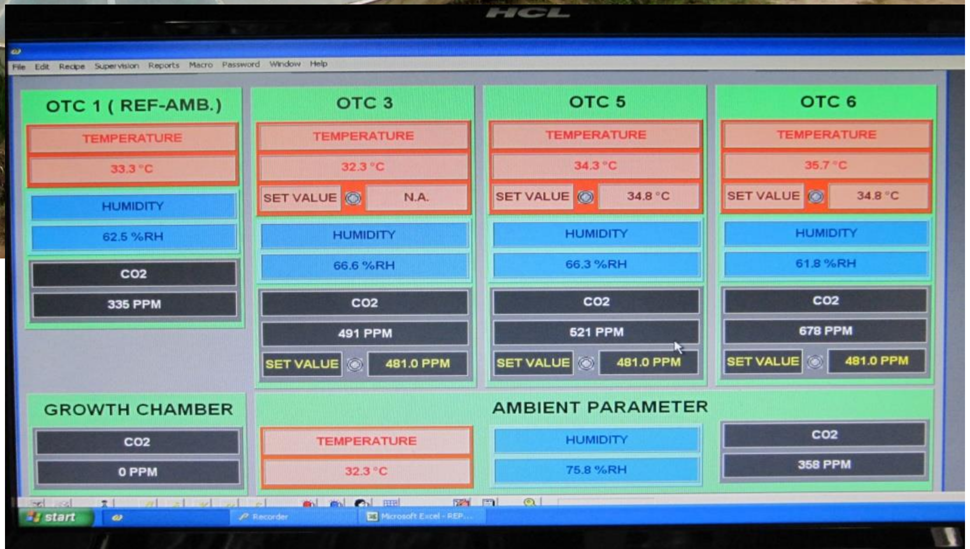
Expected change in Minimum Temperature in North Orissa
Minimum Temperature deg C
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Winter
Summer
Monsoon
Post monsoon
Annual
Season
North Orissa


Expected change in Rainfall in North Orissa
120.0
100.0
80.0
60.0
40.0
20.0
0.0
-20.0
Rainfall, mm
Winter
Summer
Monsoon
Post monsoon
Annual
Season
North Orissa

Percent Organic Carbon and Available Soil Nitrogen as Influenced by Elevated CO_2

CO_2	Organic carbon %	Soil Nitrogen (kg / ha)
Ambient	0.442	143.8
25% more	0.333	146.5
50% more	0.257	136.9
75% more	0.237	137.7
Mean	0.323	140.0
SD	0.117	26.39

OTC 1 to 8 with CO_2 treated samples
Out side plantings are used as ambient



Experimental conditions: Two series of OTCs:
Date of exposure: 15.9.2010
Date of data harvest: 30/9/2010 (15d), 15/102010 (30d), 30/10/2010 (45d)

Sl. No.	Series 1 Rice - Rice	Series 2 Rice - wheat	CO_2, ppm	Remarks
1	OTC 1	OTC 2	380	Ambient
2	OTC 3	OTC 4	470	25% more CO_2
3	OTC 5	OTC 7	565	50% more CO_2
4	OTC 6	OTC 8	660	75% more CO_2

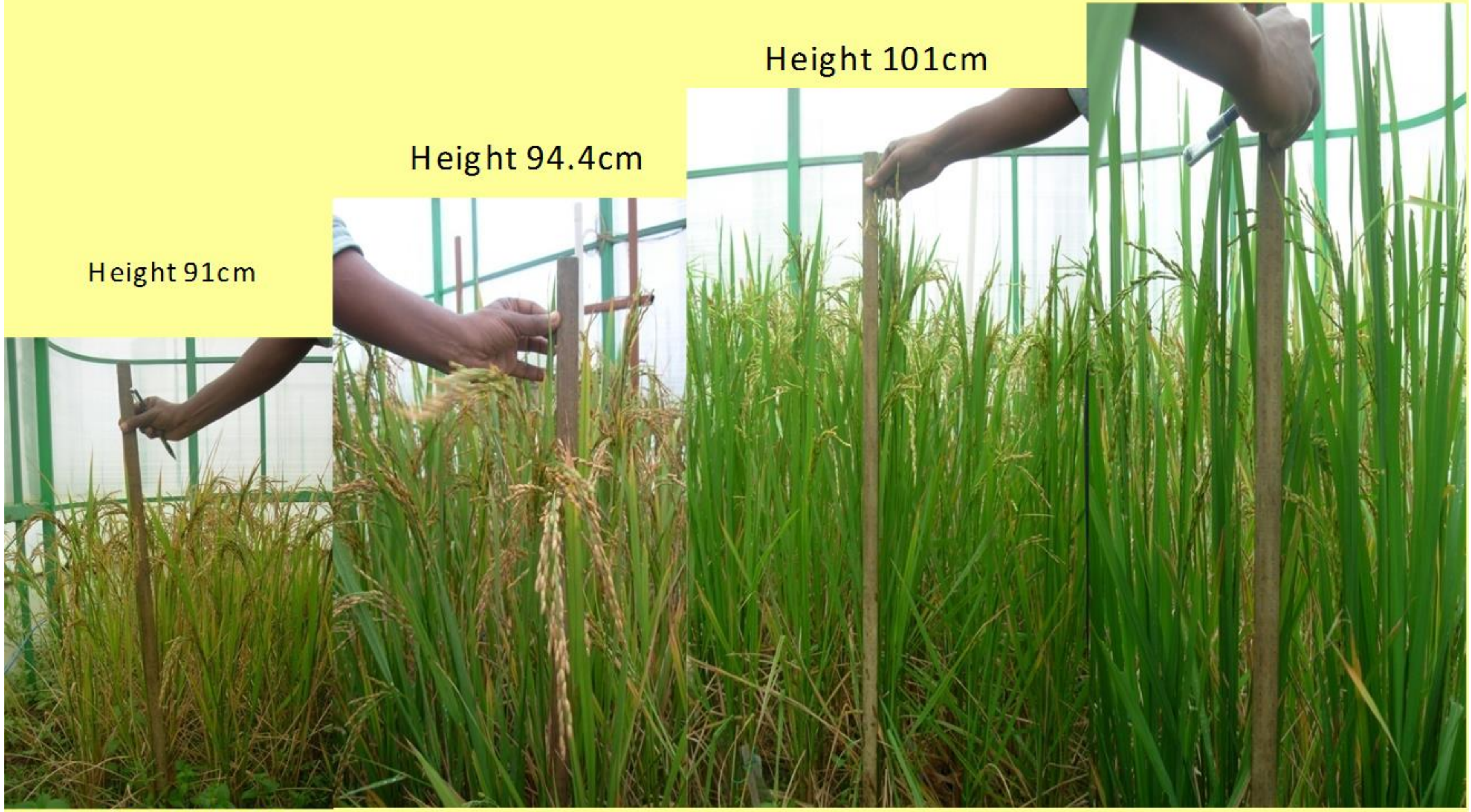
17 The Height of Rice Var. Swarna Affected by CO_2 Enrichment

Height 114cm

Height 101cm

Height 94.4cm

Height 91cm



Open Field (380 ppm CO_2)

OTC 490 ppm CO_2

OTC 585 ppm CO_2

OTC 700 ppm CO_2

Effect of elevated CO_2 on root(fresh) biomass

OTC- 8

OTC- 7

OTC- 4

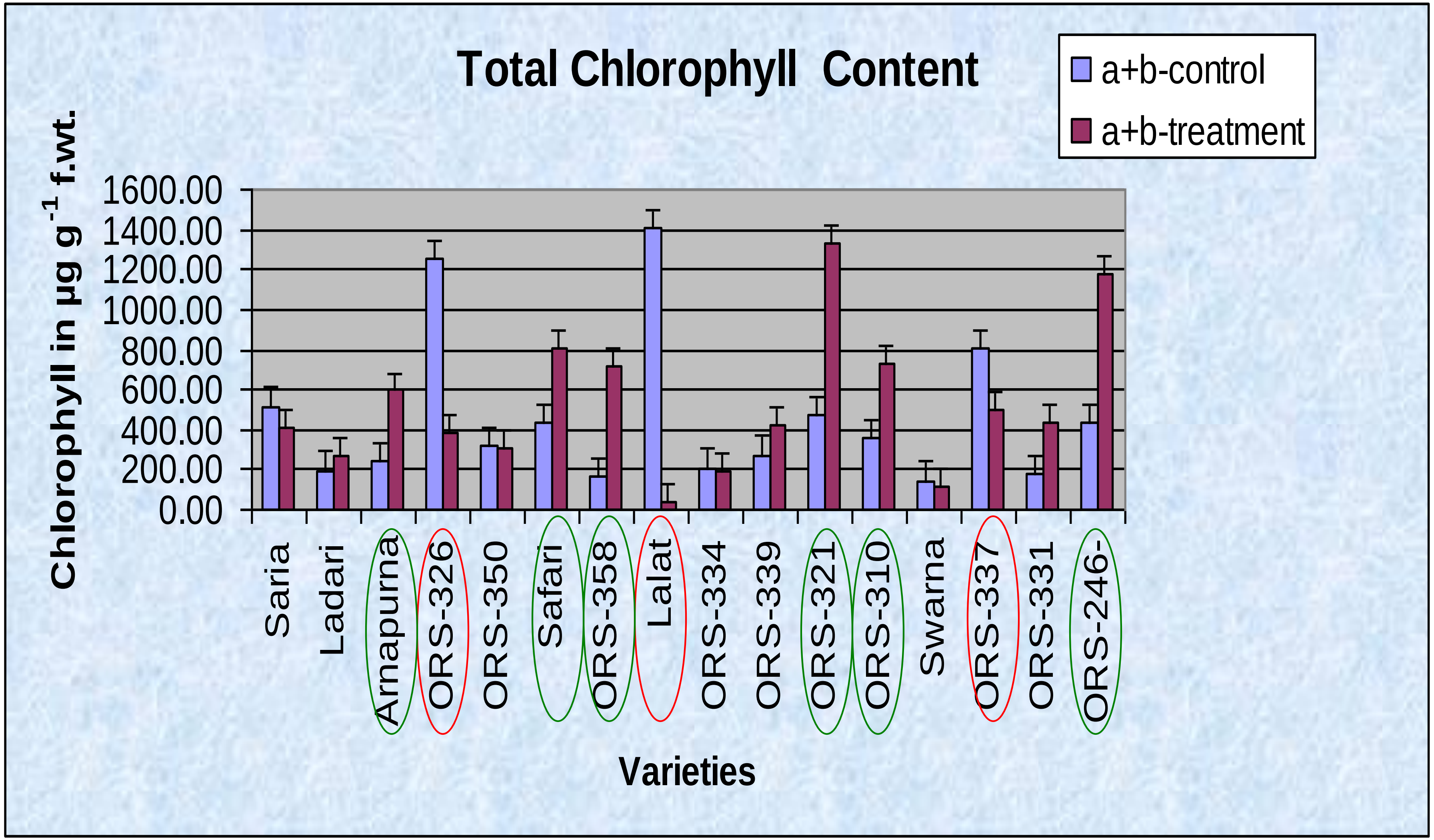
Effect of Elevated CO_2 on Agronomic Characteristics (Mean over 4 varieties)

CO_2	Chaffy grain no.%	Fill grain No.%	Total wt./ hill (g)	% leaf wt.	%Stem wt.	% panicle wt.	1000 grain wt. (g)	Total wt. q/ha	Straw wt. q/ha
25%	31.70	26.18	59.37	13.71	19.04	42.40	38.57	21.66	100.77
50%	33.75	23.68	77.84	17.61	17.86	41.12	41.03	21.35	108.22
75%	36.30	25.39	63.51	16.83	16.40	42.59	41.01	22.61	132.90
Mean	33.92	25.08	66.91	16.05	17.77	42.03	40.20	21.87	113.96
Sd	23.54	6.82	33.67	6.02	5.49	7.20	8.65	2.19	13.83

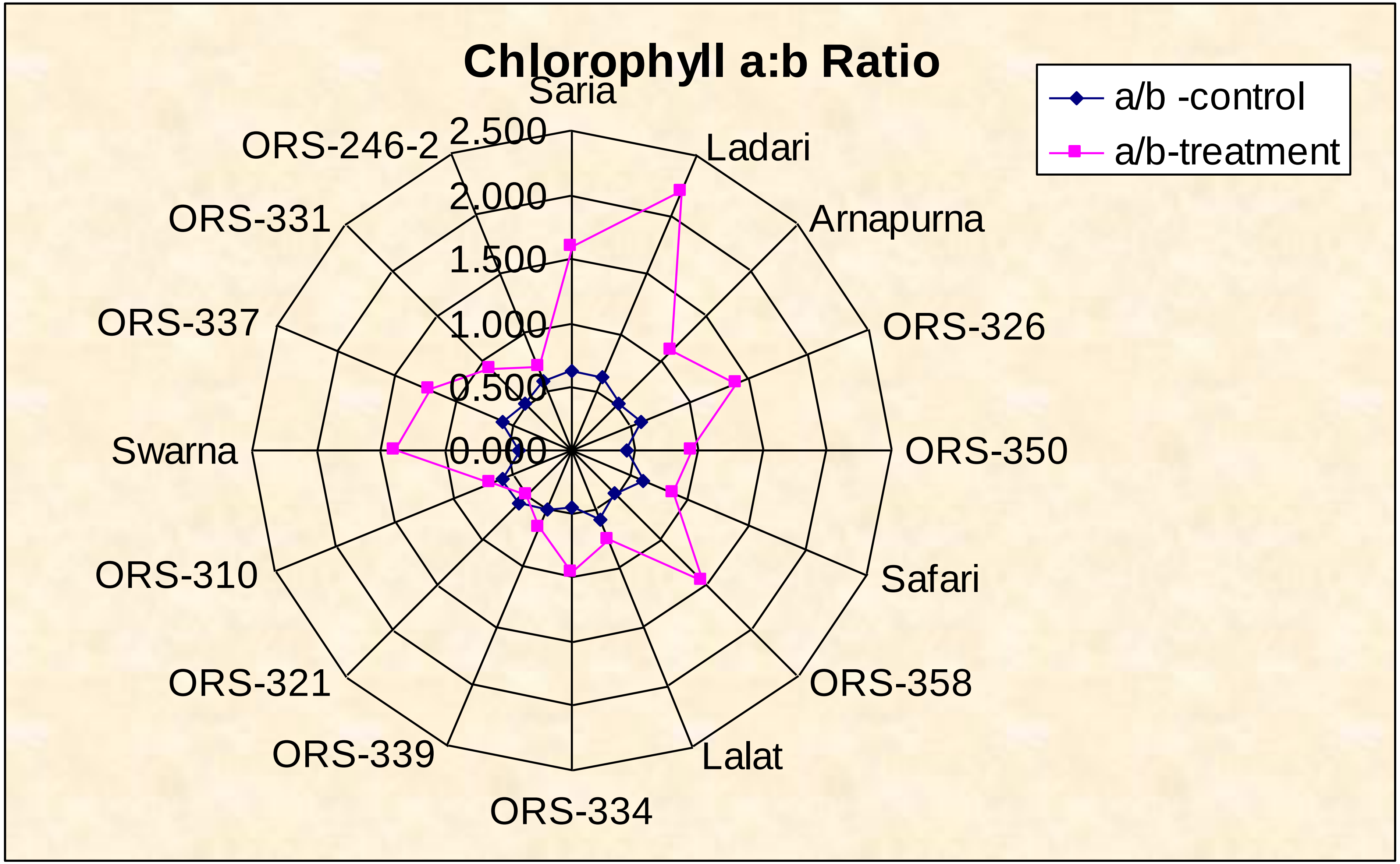
Effect of Elevated CO_2 On Agronomic Characteristics (Mean Over 16 genotypes)

CO_2, ppm	Chaf no/hill	Chaf no (%)	Chaf wt./hill (g)	Grain no/hill	Leaf wt./hill (g)	Panicles wt./hill (g)	Stem wt./hill (g)
476	53.9	46.24	0.51	129.3	2.38	4.01	6.20
660	84.6	50.07	1.61	162.1	3.08	3.46	6.79
Sd	41.9	23.29	0.74	45.9	0.86	1.43	1.57

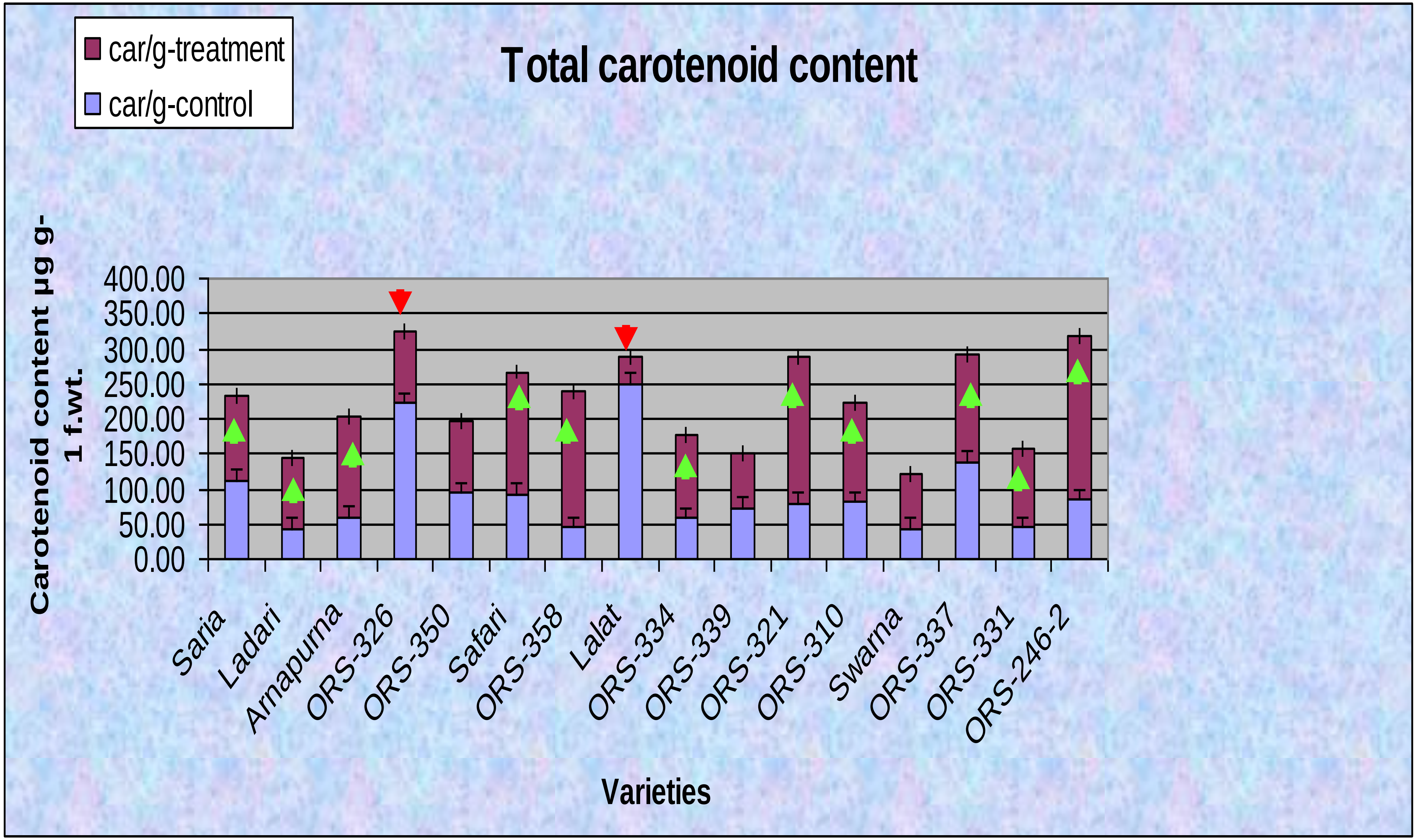
Screening of Superior Genotypes Adaptable to High CO_2 (660 ppm)



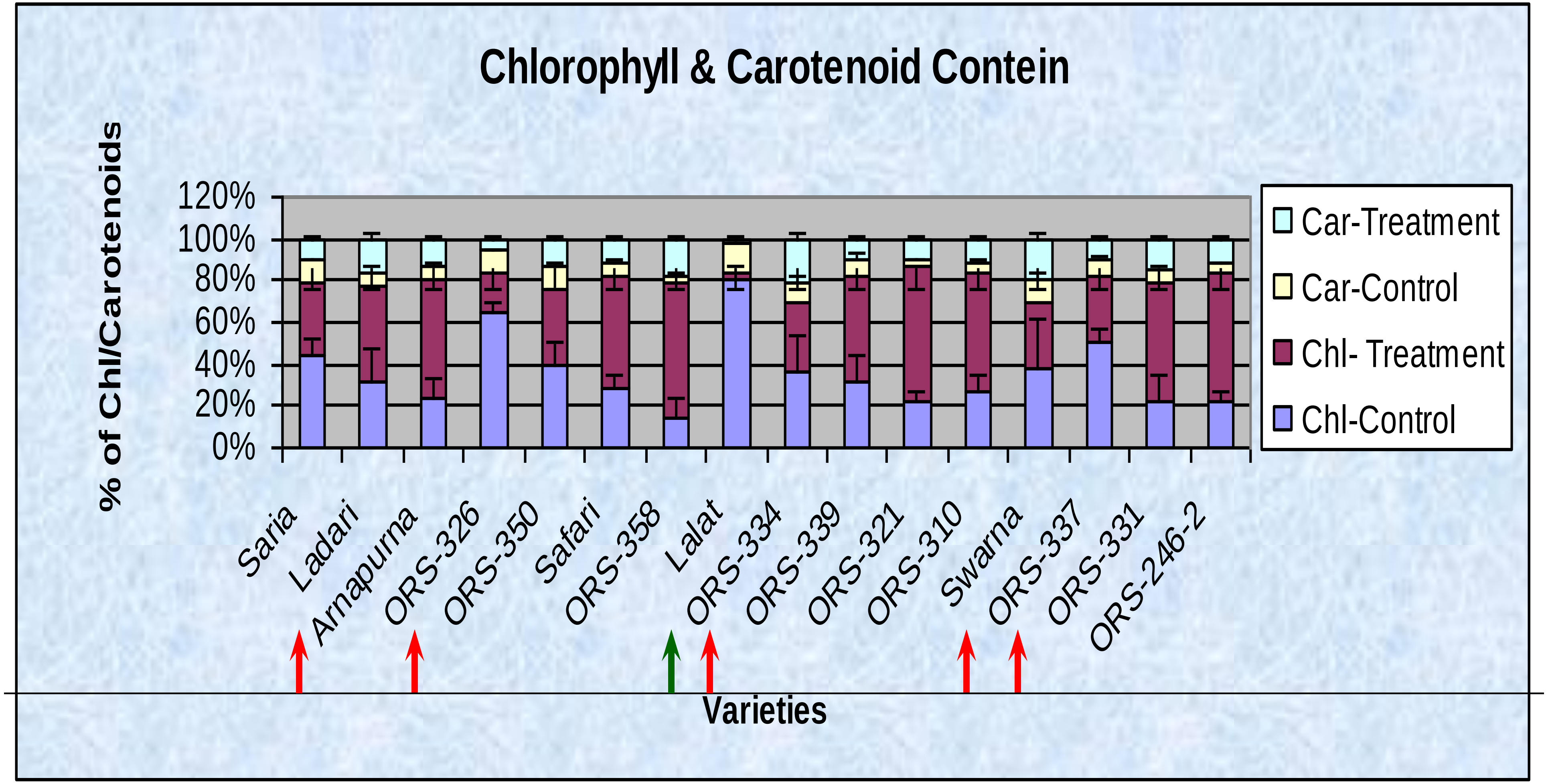
Screening of Superior Genotypes Adaptable to High CO_2 (660 ppm)



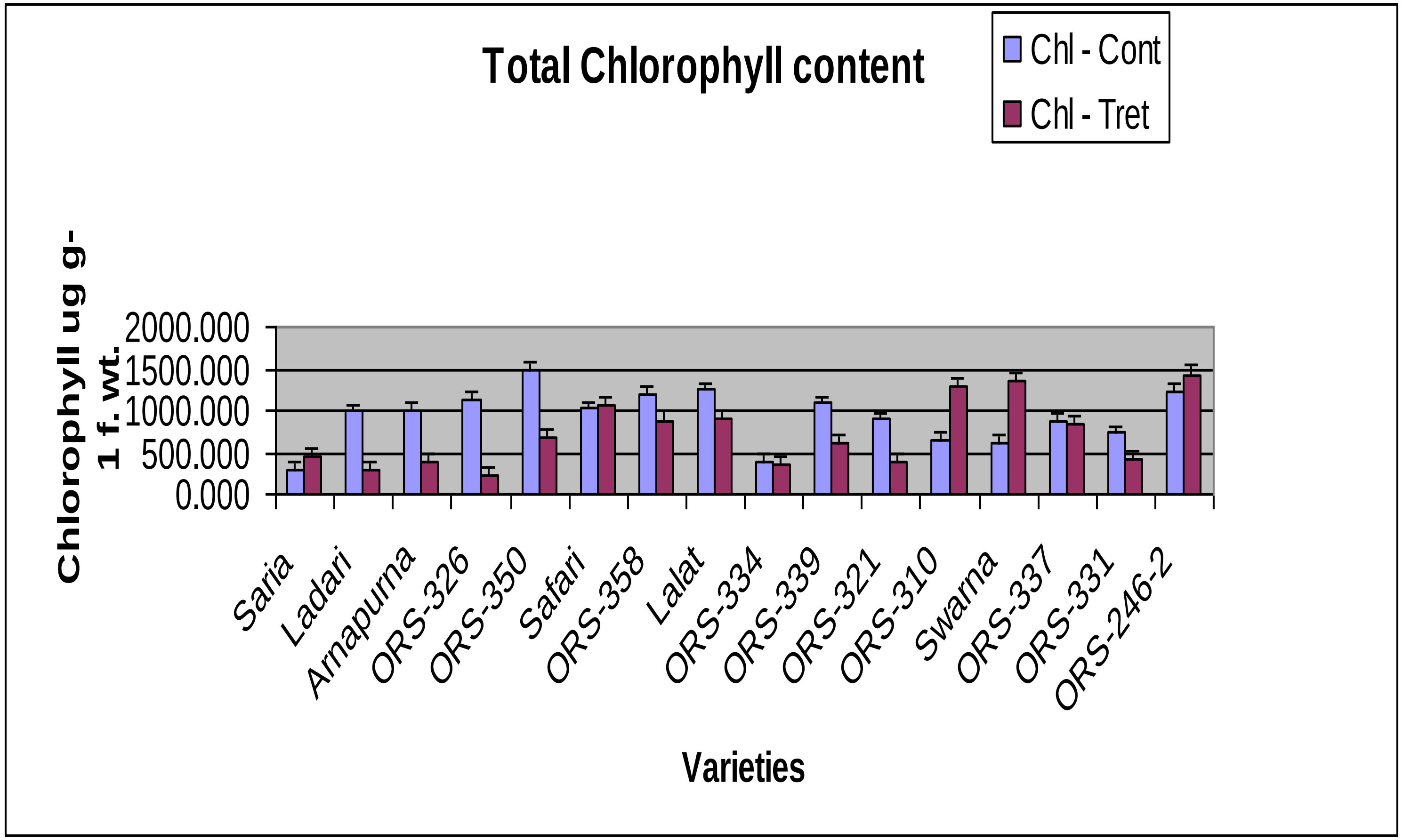
Screening of Superior Genotypes Adaptable to High CO_2 (660 ppm)



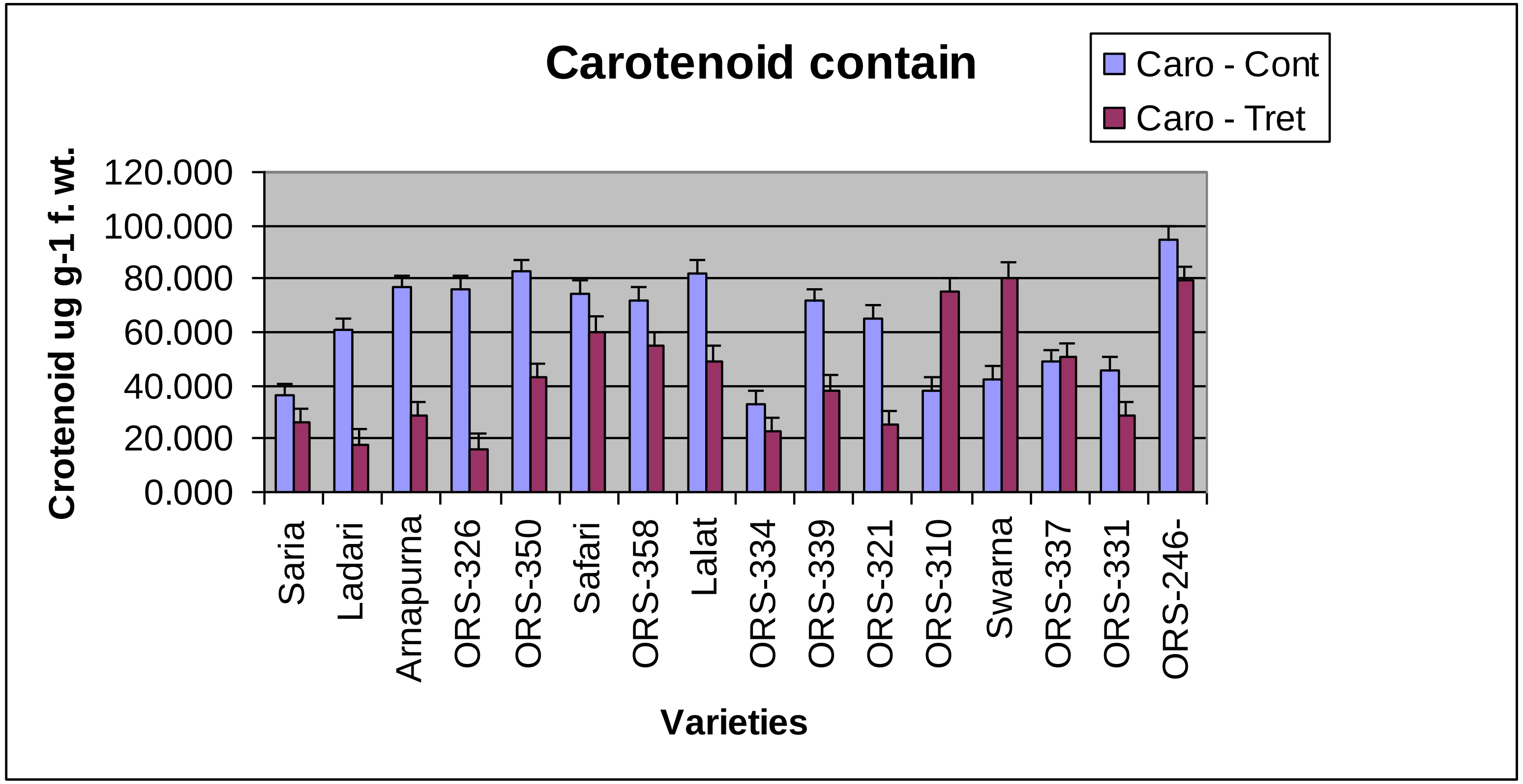
Screening of Superior Genotypes Adaptable to High CO_2 (660 ppm)

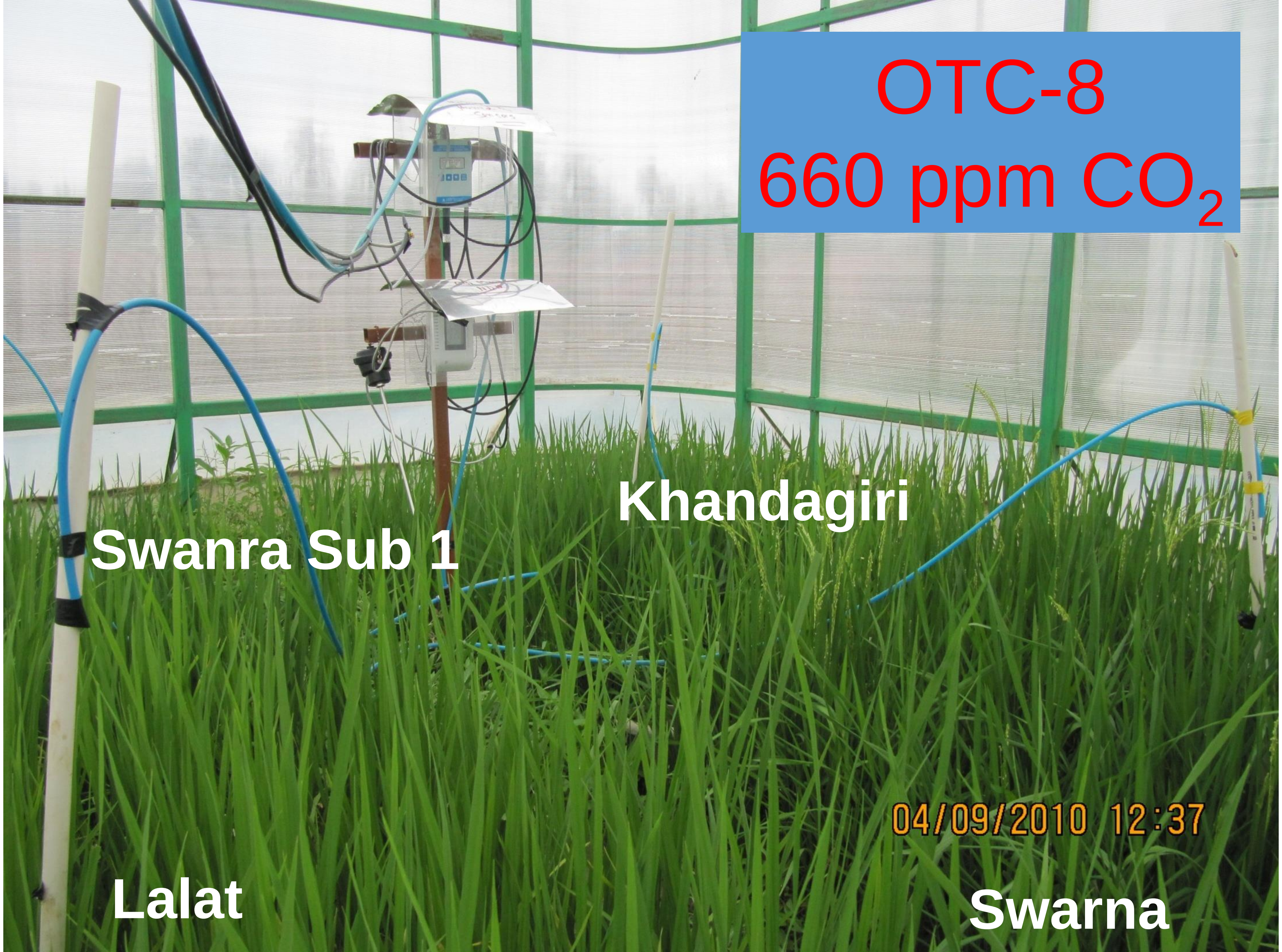


Screening of Superior Genotypes Adaptable to High CO_2 (470 ppm)

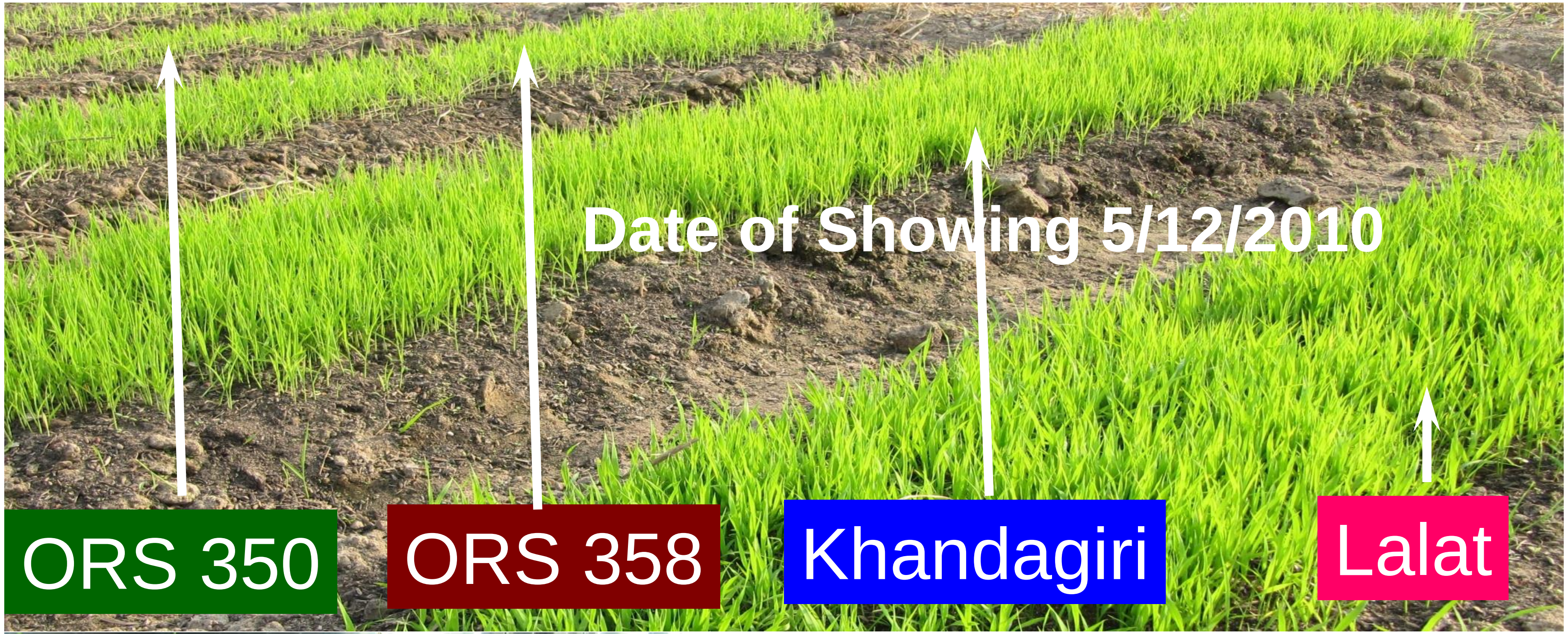


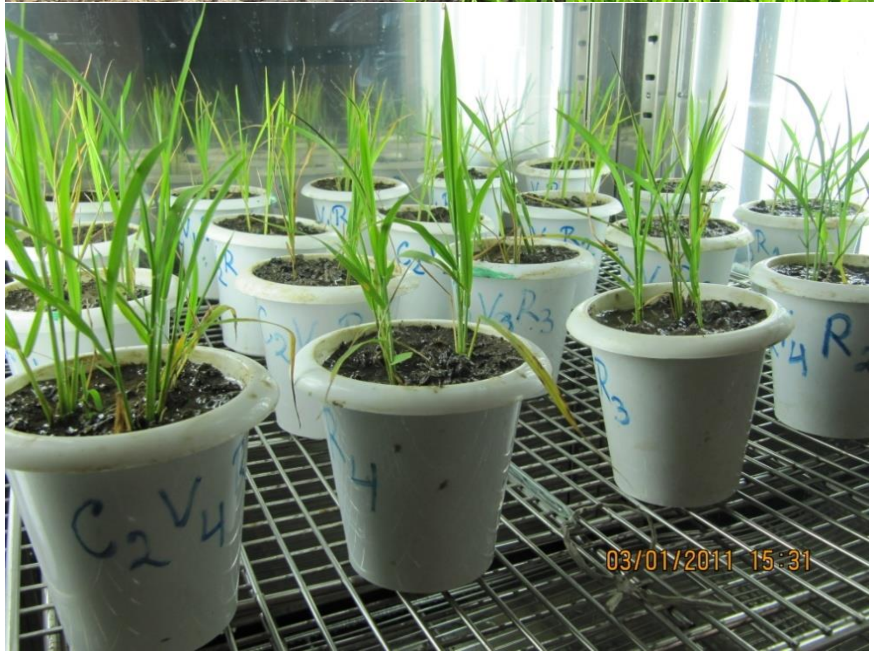
Screening of Superior Genotypes Adaptable to High CO_2 (470 ppm)





OTC-8
660 ppm CO_2
Khandagiri
Swanra Sub 1
04/09/2010 12:37
Lalat
Swarna


Date of Showing 5/12/2010
ORS 350
ORS 358
Khandagiri
Lalat


03/01/2011 15:31


DATA SCANNER
2
478
03/01/2011 15:32

What to do?

Assessment of Photosynthetic efficiency in Khandagiri, Lalat, ORS 350, ORS 358 under *in vitro* condition (470 ppm -25% increase above ambient) and validation.

Nuclear DNA profiling of rice var. Lalat, Khandagiri, ORS-350, ORS-358 in high CO_2 (470 ppm) using ISSR, SSR markers establishment.

Isolation of cpDNA and its profiling using DNA markers.

Cloning of specific DNA markers

Conclusion and Recommendation

- To increase the poverty line of the local inhabitants those who depend on mangroves for their fuelwood, timber and fodder requirements even if collection is illegal.
- To check the increasing population, resulting in more pressure on mangroves.
- Prompting education and awareness regarding the importance of mangroves, and ignorance of rules and regulations regarding conservation of mangroves.
- Proper planning of development activities such as aquaculture, agriculture, construction for human habitation, mining and industrialization.

Conclusion and Recommendation

- Alternative arrangement of fuelwood, timber and fodder at affordable prices;
- Systematic survey of the area and the ownership of the land under mangroves, facilitating encroachment on this land.
- Proper mapping of scattered geographic distribution of mangroves.
- Increase of government staff and other infrastructure and involvement social forestry programme of local people.


Thank You !!!