Impacts of Climate Change to Agriculture
Biological Diversity

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Outline of presentation

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4. Climate Change Impacts On Agrobiodiversity
5. Agrobiodiversity As An Adaptive Component to Climate Change
6. Research Gaps, Needs And Way Forward
7. Activities On Agrobiodiversity In MARDI
8. Conclusions
Climate change: threat facing today’s world

- Any change in climate over time that directly and indirectly affects human and their activities as well as natural systems and processes. Impacts could:
  » Undermine development
  » Affect human well-being
  » Threaten security of natural resources

Dry seasons will have less rainfall. There will be an increase in irrigation water demand unless offset by diversification with dry-food crops

Global Scenario of Climate Change

- Many species will disappear, many will face problems in surviving.
- Frequency of tropical cyclones will increase.
Climate Change in Malaysia

Peninsular Malaysia ~ 0.5°C per Century

Malaysia ~ 0.1°C per Decade

Source: IPCC, 2007
Projections by NAHRIM

- Annual rainfall in Kelantan, Terengganu, Pahang and N-W coast – increase up to 10%
- Annual Rainfall in Selangor and Johor - decrease by 5%
- Overall, mean air temperature - increase by 1.2 to 1.4°C
- Minimum temperature - increase by 0.7-1.4°C
- Maximum temperature - increase by 1.6-2.0°C

Sectoral Vulnerability

Southeast Asia

<table>
<thead>
<tr>
<th>Sector</th>
<th>Vulnerability</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food &amp; Fiber</td>
<td>Highly</td>
<td>High</td>
</tr>
<tr>
<td>Water Resource</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>Biodiversity</td>
<td>Highly</td>
<td>High</td>
</tr>
<tr>
<td>Coastal Ecosystem</td>
<td>Highly</td>
<td>High</td>
</tr>
<tr>
<td>Land degradation</td>
<td>Highly</td>
<td>High</td>
</tr>
</tbody>
</table>

IPCC; AR4: Vulnerability; highly, moderately, moderately resilient
Confidence; V. high, high, medium, low
Climate Change Impacts on Agriculture

Positive impacts
- Increased productivity from warmer temperature
- Possibility of growing new crops
- Longer growing season
- Increased productivity from enhanced CO2
- Accelerated maturation rates
- Decreased moisture stress

Projected changes
- Warmer temperature
- Drier or wetter condition
- Increased frequency of extreme climatic events
- Enhanced atmospheric CO2
- Changing market conditions

Negative impacts
- Increased insect infestations
- Crop damage from extreme heat
- Planning problems due to less reliable forecasts
- Increased weed growth and disease outbreaks
- Decrease herbicide and pesticide efficiency
- Increased moisture stress and drought

CLIMATE CHANGE IMPACTS ON AGROBIODIVERSITY

Climate Change

Direct

Effects on Organisms (Physiological, etc.)

Indirect

Effects on Disturbance Regimes

Ecosystem Structure, Composition, and Function
Impacts of Climate Change on PGRFA

- Rain-fed agriculture will be highly affected by total reduction in precipitation.
- Impact on rain-fed rice cultivation from seasonal shift and change in rainfall pattern.
- Impacts on agriculture due to high evaporation loss of moisture from soil.
- Frequent and prolonged drought.

Rice – climate interaction

- An increase 1°C daily average may result in a 10% yield reduction.
- High night T° may cause reduction in CHO reserves and lead to an increase in empty grain.
- Current simulation study for MADA area: with a 2°C rise in temperature, rice yield expected to drop from 8 ton/ha to 7 ton/ha.
Impacts of Climate Change on Arthropods

- Climate change is likely to alter the balance between insect pests, their natural enemies and their hosts.

- Under a warmer climate, exotic pests could establish populations in places that it never been found before such as migration of insect species to higher altitude.

- Synchrony between host and insect pest development, the predicted rise in temperature will also generally favour insect development.

- Climate change is likely to significantly alter the frequency of insect migrants, including introducing some agricultural pests that are completely new to the place. Invasive species could be a problem too.
Impacts of Climate Change on Microbial Resources

- Reduce microbial activities which affects nutrient and carbon cycle and organic matter decomposition
- Climate change was suspected as a reason why a deadly new version of a tropical fungus is spreading in the temperate climate
- Climate change may lead to discovery of more new fungi or mushroom species

Impacts of Climate Change on Ecosystem

**ECOSYSTEM SERVICES**

- **Provisioning**
  - FOOD
  - FRESH WATER
  - WOOD AND FIBER
  - FUEL
  - ...

- **Supporting**
  - NUTRIENT CYCLING
  - SOIL FORMATION
  - PRIMARY PRODUCTION
  - ...

- **Regulating**
  - CLIMATE REGULATION
  - FLOOD REGULATION
  - DISEASE REGULATION
  - WATER PURIFICATION
  - ...

- **Cultural**
  - AESTHETIC
  - SPIRITUAL
  - EDUCATIONAL
  - RECREATIONAL
  - ...
**Impacts of Climate Change on Ecosystem**

- Changes in distribution of species, ecosystems boundaries and biomass
- Changes in phenology of biotic and abiotic processes
- Changes in structure of plants communities
- Increased pests and diseases

**AGROBIODIVERSITY AS AN ADAPTIVE COMPONENT TO CLIMATE CHANGE**

**Mitigation**
- In situ conservation of adapted biodiversity
- On-farm conservation and crop management
- Use IPM options to reduce vulnerability to changes in pathogen distribution
- Better matching of adapted germplasm to climate variability
AGROBIODIVERSITY AS AN ADAPTIVE COMPONENT TO CLIMATE CHANGE

**Adaptation**
- Selection of plants and livestock that tolerant to heat & drought
- Cropping system and cropping pattern- Multiple cropping & Agro-forestry
- Species mixtures will provide some insurance against climate change - not all will be affected to the same extent
- Conservation of wild relatives of food crops as insurance for the future

RESEARCH GAPS, NEEDS AND WAY FORWARD

- Lack of information systems for genetic resources especially on climate change related traits
- Lack of support for ex situ and in situ conservation for genetic diversity resources that could adapt to multiple new stresses (drought, new pest and diseases)
- More International cooperation is needed as part of a long-term strategy to confront climate change.
- Lack of information on effects of climate change on insect pests and diseases
RESEARCH GAPS, NEEDS AND WAY FORWARD

- Conservation, characterization and sustainable use of genetic diversity and plant improvement
- Collection and use of commercially promising and/or underutilized plants
- Dynamics of pests and diseases under changing climates
- Strong coordination between main global programmes such as UNFCCC, CBD, International Treaty on PGRFA
- Agrobiodiversity conservation to be made a basic component of adaptation strategies to climate change
- Management of agrobiodiversity resources require re-orientation in their strategies i.e. In-situ conservation must be made an integral part of agricultural development and be supplemented by ex-situ conservation
Activities On Agrobiodiversity In MARDI

Biological resource management and utilisation

- Bioprospection, utilization and conservation of biodiversity of plants
- Conservation and utilization of arthropod diversity important to agriculture
- Conservation and sustainable utilization of microbial diversity important to agriculture
- Ecosystem approach in agrobiodiversity conservation
- Agrobiodiversity information system

Field Gen bank

- Pulaskan: 40 acc.
- Durian Liar: 38 acc.
- Mangifera: 160 acc.
- Pisang: 400 acc.
- Buahan nadir: 584 acc.
Location of Field GenBank

- **Bukit Tangga**
  - (Mangifera, Zapota, Nephelium & Durio spp)

- **Bertam**
  - (Rice & traditional vegetables)

- **Jerangau**
  - (Salacca, Lansium, Durio & herbs)

- **Kuala Kangsar**
  - (Durio & Citrus spp)

- **Hilir Perak**
  - (Cocos nucifera)

- **Kemaman**
  - (Durio, Lansium, Arthocarpus & Garcinia)

- **Kluang**
  - (Arthocarpus, Carambola, rare fruits, Beverages & herbs)

- **Serdang**
  - (Fruits, herbs & arthropod and microbial culture collections)

- **Kuala Kangsar**
  - (Durio & Citrus spp)

- **Hilir Perak**
  - (Cocos nucifera)

- **Serdang**
  - (Fruits, herbs & arthropod and microbial culture collections)

DIVERSITY OF DURIO SPECIES

- **Tutong** (Durio dulcis)
- **Durian kening** (D. graveolens)
- **Durian merah** (D. graveolens)
- **Durian paya** (D. carinatus)
- **Durian (D. lowianus)**
- **Durian sangka** (D. lowianus)
- **Sukang** (D. testudinarium)
- **Nyekak** (D. kutejensis)
- **Duriaban** (D. lanceolatus)
- **Durian kura kura** (D. testudinarium)
DIVERSITY OF MANGIFERA SPECIES

Binjai (Mangifera caesia)

Mangifera caesia (Mangifera odorata)

Rawa (Mangifera griffithii)

Asam kumbang (Mangifera quadrifida)

Bacang (Mangifera foetida)

Sepam (Mangifera longipetiolata)

Mempelam (Mangifera pentandra)

Mangifera laurina

Elite Pulasan Acc. Elite Pulasan Acc.

Accession 15

Sarcotesta detached: Good
Sarcotesta taste: Sweet
Sarcotesta juiciness: Juicy
Total score: 47.65

Accession 65

Sarcotesta detached: Good
Sarcotesta taste: Sweet
Sarcotesta juiciness: Juicy
Herbs & Medicinal Plants Field Genebank; Jerangau

Kacip Fatimah 50 acc.
Zingiber 127 acc.
Limau Purut 20 acc.
Tuba 17 acc.
Tongkat Ali 7 acc.
Other species >1500 acc.

Underutilised fruits spp with high nutritional & antioxidant properties identified

- Ceri Terengganu
- Psidium littorale
- Garcinia parvifolia
- Kerkup
- Flacourtia jangkouos
- Belimbing buluh
- Averrhoa bilimbi
- Cerapu
- Garcinia prainiana
Traditional vegetable and ulam species high in antioxidant, vitamins and iron identified

- Phytochemical content (total phenol, antioxidant activity and iron content) of 10 ulam species analysed
- Bebuas (1/6) acc., beluntas (7/14) acc., gajus (30/42) acc. showed high antioxidant activity (FRAP assay) more than 70% radical scavenging effect and can be potentially planted for larger scale
- Potential accessions with high antioxidant activity that could be recommended for field planting:
  - Bebuas (EST 07-0201)
  - Beluntas (STN 07-0263, STN 07-0266, EST 07-0287, STN 07-0202)
  - Gajus (25 out of 30 accessions)

Seed Genebank Seberang Perai

- Short-term (3-5yrs): 19-21°C, RH 50-60%
- Medium-term (~15yrs): 3-5°C, RH 35-45%
- Long-term (~30yrs): -20°C
Seed Genebank Seberang Perai

<table>
<thead>
<tr>
<th>Rice</th>
<th>11,940 acc.</th>
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Indigenous Vegetables

<table>
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<tr>
<th>Vegetable</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>Terung</td>
<td>25 acc.</td>
</tr>
<tr>
<td>Cili Besar</td>
<td>7 acc.</td>
</tr>
<tr>
<td>Cili Api</td>
<td>48 acc.</td>
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<tr>
<td>Amaranth</td>
<td>11 acc.</td>
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<tr>
<td>Petola Ular</td>
<td>9 acc.</td>
</tr>
<tr>
<td>Terung Pipit</td>
<td>10 acc.</td>
</tr>
<tr>
<td>Terung Bulu</td>
<td>10 acc.</td>
</tr>
<tr>
<td>Kacang Botor</td>
<td>12 acc.</td>
</tr>
<tr>
<td>Others</td>
<td>368 acc.</td>
</tr>
</tbody>
</table>


- Oil formulations from *Pelargonium radula* (jeremin) & *Cymbopogon citratus* (serai makan) are potential biopesticidal agents.
- Scientific investigation showed the effectiveness of the oil formulations against agricultural pest – *Plutella xylostella* (diamond-back moth) using bioassay method.
Mardi Arthropod Collection

- Established in early 1980's
- Current collection - more than 29,000 specimens from various agroecosystems
- 29,348 specimens; Pests, biocontrol agents, pollinators and other functional groupings
- Believe to be the largest collections of insects in Malaysia
Diversity of Arthropod Species on Herbs

Biocontrol

Three main kinds of biological control:

- Introduction of exotic species of parasitoids and predators
- Conservation of native parasitoids and predators and
- Augmentation of parasitoids and predators

Newly encountered parasitoid:

Oomyzus sp. parasitizing the larva of tiger moth on tongkat ali.
## Microbial Resources Conservation and Utilization

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<tbody>
<tr>
<td>Fungus</td>
<td>566</td>
<td>1132</td>
<td>16</td>
</tr>
<tr>
<td>Actinomycetes</td>
<td>0</td>
<td>655</td>
<td>376</td>
</tr>
<tr>
<td>Bacteria</td>
<td>48</td>
<td>358</td>
<td>358</td>
</tr>
<tr>
<td>Yeast</td>
<td>6</td>
<td>5</td>
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## Bioprospection of Beneficial Microbes

<table>
<thead>
<tr>
<th>Application</th>
<th>Microbial Group</th>
<th>Isolates</th>
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</thead>
<tbody>
<tr>
<td>Biofertilizer</td>
<td>N-Fixing Bacteria.</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>P-Solubilizing Bacteria</td>
<td>55</td>
</tr>
<tr>
<td>Biopesticide &amp; Bio herbicide</td>
<td>Exsehllum spp.</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>Actinomycetes</td>
<td>16</td>
</tr>
<tr>
<td>Volatile Fatty Acid degrader</td>
<td>Bacteria</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>Actinomycetes</td>
<td>50</td>
</tr>
<tr>
<td>Cellulose degrader</td>
<td>Fungus</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>Bacteria</td>
<td>44</td>
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<tr>
<td></td>
<td>Actinomycetes</td>
<td>500</td>
</tr>
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</table>
**Virus Based; Biopesticides**

Environment Friendly Virus based Biopesticide for controlling Armyworm, Spodoptera litura

- Novelty: Stable NPV
- Advantages:
  - Room Temp. storage
  - Longer shelf life
  - Added with UV protectant

**Crude/Semipurified NPV S. litura**

**Formulated NPV S. litura**

**Fungus Based Bioherbicide**

To control rumput sambau (Echinochloa spp.) in Rice

The utilization of indigenous fungus isolated from naturally infected barnyard grass and the usage of recycled oil palm product as the ingredients in the formulation.

The lysis activities of bacteriophages against Ralstonia solanacearum on agar plate.

Tomato plants inoculated with bacteriophages.

Agrobiodiversity Information System
Conclusions

- Genetic resources are crucial to cope with climate change
- Conservation of agricultural biodiversity is a key option for the adaptation to climate change
- Maximum of genetic resources has to be conserved as the future needs for human survival
- Association between climate change and loss of biodiversity required more holistic framework and approaches to solve common problems
- Combination of mitigation and adaptation need to be addressed simultaneously