Case Study:
Stress Tolerant Varieties of Rice

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Introduction:

Land Used

- Rice: 48.76%
- Field crops: 20.91%
- Fallow: 21.97%
- Fruit & Trees: 2.77%
- Vegetables & Flora: 0.95%
- Forage crops: 0.87%
- Others: 0.1%
- Residents: 0.1%

Aerable Land: 20.8 mha
Rice area map of Thailand

Rainfed rice area (75%)

Irrigated rice area (25%)

Total area 10 M ha

By courtesy of Chitnucha (2017)
Rice area (million ha) in 4 sub-ecosystems

- Rain-fed: 7.2 m ha (72%)
- Irrigated: 2.0 m ha (20%)
- Upland: 0.3 m ha (3%)
- Deep water: 0.5 m ha (5%)
Major rice topography

Introduction

Adapted from Chitnucha (2017)
CROPING SEASONS: and Major Type of Cultivated Rice Variety

- **Wet Season (Major rice)**
  - July ~ November
  - Photoperiod sensitive varieties

- **Dry Season (Second rice)**
  - January ~ May
  - Photoperiod insensitive varieties
Planting Practices

- Dry seed drilling
- Dry seed broadcasting
- Dry seed drilling by machine
- Pre-germinated seed broadcasting
- Transplanting
- Dry seed broadcasting
ปัจจุบันนิยมใช้เครื่องหยอดเมล็ด ทั้งแบบแห้ง และแบบเปียก

Transplanting Machine

Combined Harvester
Stresses:

Abiotic stresses – Water, Soil, Temperature

Biotic stresses – Diseases, Insect pests
Climate change induce water stresses e.g. drought and flood, because of uneven rainfall distribution.

Fig. Flooding during flowering stage of rain-fed rice
Fig. Drought during vegetative stage of rain-fed rice
Water shortage in irrigated rice production area
Research Schemes of Rice Dept.:

1. Increasing yield potential and production efficiency
2. Reducing yield losses and stabilizing yield
3. Retaining high grain quality
4. Climate change adaptability and mitigation
5. Self-sufficient rice production for food security in specific area

6. Value adding and special rice for niche market

7. Low production cost technology
Abiotic Stress Tolerant Varieties:

I. Drought

Genotypic:
Complicated
Quantitative Trait Loci (QTLs)

Phenotypic:
Shoot, Root

Physiological:
Evapotranspiration
Leaf Water Potential
Leaf Temperature
Phenotypic characterization of drought avoidance and drought tolerance traits in selected KDML105 chromosome segment substitution lines (CSSL) harboring full QTL segment under field experiments

By courtesy of Suwat (2017)

Presented in the meeting at Sakon-Nakhon Rice Research Center
2 March 2013
Line source sprinkler irrigation system (CPA)

By courtesy of Suwat (2017)
Field layout

The line source sprinkler irrigation

Irrigation levels

Genotypes direction

Rep I

Rep II

By courtesy of Suwat (2017)
Data collections

Flowering date, Visual score and Panicle exertion rate

Predawn LWP (24:00 - 03:00 am)

Midday LWP (12:00 - 15:00 pm)

Grain yield and Yield components

By courtesy of Suwat (2017)
Drought score

Score 1

Score 3

Score 5

Score 7

Score 9

Leaf rolling score

Score 1

Score 2

Score 3

Score 4

Score 5

By courtesy of Suwat (2017)
Severity of Drought at CPA

<table>
<thead>
<tr>
<th>Grain yield (kg/rai)</th>
<th>Irrigation level</th>
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<tr>
<td>Yield loss &gt; 50%</td>
<td>21</td>
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<tr>
<td></td>
<td>172</td>
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<td>456</td>
</tr>
</tbody>
</table>

By courtesy of Suwat (2017)
Drought resistance mechanisms (Mackill et al., 1996)

- **Root-related traits:**
  - Deeper and denser root system
    *(Increased water uptake)*

- **Shoot-related traits:**
  - Stomatal closure, leaf rolling, thicker epicuticular wax, osmotic adjustment
    *(Maintenance leaf water potential and turgor potential)*

- **Reproductive stage specific:**
  - Increase panicle diffusive resistance, early morning anthesis
    *(flower at higher panicle water potential)*
  - Emergence of new panicles from internodes
    *(Recovery of lost yield component)*
  - **Remobilization and translocation of stored reserves**
    *(Maximization of potential harvest index)*

*By courtesy of Suwat (2017)*
Root Morphology related to drought tolerance

- Root length or depth
- Lateral root branching
- Root angle
- Root hairs
- Root aerenchyma
Genotyping rice chromosome segment substitution lines to facilitate gene discovery for root characteristics

By courtesy of Panchita (2017)
Harvest at 60 days after sowing.

By courtesy of Panchita (2017)
Significant phenotypic variation of lateral root branching

By courtesy of Panchita (2017)
Quantitative Analysis of Root Hair Traits

By courtesy of Panchita (2017)
Substantial phenotypic variation in root hairs has been observed.

Root hair length and density vary independently among genotypes in rice.

By courtesy of Panchita (2017)
Root aerenchyma

By courtesy of Panchita (2017)
II. Flood and Submergence

Abiotic Stress Tolerant Varieties:

1. Deep-water rice, Floating rice (Stem elongation ability)
2. Submergence tolerant
Deep-water rice

Stem elongation ability

Floating rice
Plai Ngahm Prachinburi (PGM)
Submergence tolerant varieties: IR64-sub1, Swarna-sub1, ข้าว51 (RD51)
Flood affected (10 d submergence) rice fields of Arun Kumar Singh at village Khuruhuja, District Chandoli, UP, India
Rice Mutation Breeding
To Cope with Climate Change

I. Flooding Conditions

- Anaerobic germination ability
- Submergence tolerance
- Elongation ability

Currently conducting Mutation Breeding
Screening for submergence tolerant lines

By courtesy of Peera (2017)
Flooding

By courtesy of Peera (2017)
Recovery

By courtesy of Peera (2017)
Methodology for Anaerobic Germination (AG)

M₀ → M₁ → M₁ plant with M₂ seeds → M₂ plants → M₃ seeds
Screening for anaerobic germination seed

1 day after submerge

21 day after submerge
Screening for submergence tolerance (bulk selection)

Before submergence

A 14 days submerge

B 2 days after de-submerge

C Recovery period (20 days after de-submerge)

D 2 days after de-submerge
Submergence recovering evaluation
การทดสอบความสามารถทนน้ำท่วมฉับพลัน

By courtesy of Udompan (2017)
สรุปผลการทดลอง

- IRRI119-PCR-162: ข้าวทนน้ำท่วมในระยะแตกกอได้นาน 10-15 วัน ในสภาพบ่อทดลองและพื้นตัวได้ 85-95%

ผลผลิต

<table>
<thead>
<tr>
<th>ร้อยละ</th>
<th>ผลผลิตน้ำท่วม</th>
<th>ผลผลิตน้ำปกติ</th>
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<td>397 กก./ไร่</td>
<td>719 กก./ไร่</td>
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<td>661 กก./ไร่</td>
<td>49 กก./ไร่</td>
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อายุเก็บเกี่ยว 119 วัน ความสูง 116 ซม.

ลักษณะทางกายภาพ/เคมี

- ขนาดเมล็ดยาว 8.11 มม. กว้าง 2.36 มม. หนา 1.95 มม. รูปร่างเรียวท้องไข่มาก 2.12 อิมิลลิโอม 27.45%
- ปฏิกิริยาต่อโรค/แมลง: ค่อนข้างอ่อนแอบี, บีพร์, แกล, ค่อนข้างอ่อนแอบี-ปานกลาง WBPH

By courtesy of Udompan (2017)
Abiotic Stress Tolerant Varieties:

III. Adverse soil
- Salinity .... (2.7 m Ha)
- Acidity .... (1.2 m Ha)
Environment and climate condition

Drought-prone area

Flood-prone area

Drought and flood-prone area

3,910,621 ha

916,292 ha

77,271 ha

By courtesy of Chitnucha (2017)

แหล่งที่มา: กรมพัฒนาที่ดิน
Adverse Soils

Salinity stress

By courtesy of Chitnucha (2017)

By courtesy of Duangjai (2017)
Salt tolerance genetic:

QTLs “Saltol”

Genes:
- SOS1 – Na⁺
- SKC1 – K⁺

Donors:
- Pokkali
- Nonabokra
- IR66946

By courtesy of Duangjai (2017)
IV. Temperature

- Heat stress (High temp.)
- Cold stress (Low temp.)
โรงเรือนจำลองสภาพอุณหภูมิสูง

ศูนย์วิทยาศาสตร์ข้าว ม.เกษตร
ก้าแพงแสน นครปฐม

By courtesy of Peerapol (2017)
The most critical period of high temperature on the yield of rice.

(Matsui and Omasa, 2002)

By courtesy of Peerapol (2017)
Materials and Methods
Anther character of heat treatment

By courtesy of Peerapol (2017)
Spikelet character of heat treatment

Fertile spikelet

Sterile spikelet

high temperatures tolerance

high temperatures sensitive

By courtesy of Peerapol (2017)
THANK YOU