

英 100330

# RICE IN ASIA

Edited by

THE ASSOCIATION OF  
JAPANESE AGRICULTURAL  
SCIENTIFIC SOCIETIES



©UNIVERSITY OF TOKYO PRESS, 1975  
UTP No. 3061-77051-5149

Printed in Japan.

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopy, recording, or any information storage and retrieval system, without permission in writing from the publisher.

ISBN 0-86008-134-6

## PREFACE

Composed of more than twenty different academic associations of specialists in various fields of the science of agriculture in Japan, the Association of Japanese Agricultural Scientific Societies represents Japanese agricultural scientists in the most comprehensive manner.

The Association of Japanese Agricultural Scientific Societies, in close collaboration with its member societies, has been sponsoring each year several inter-disciplinary symposia on subjects of scientific importance having to do with agriculture.

Especially important among the subjects of symposia are, of course, problems involved in the cultivation and processing of rice, not only because rice occupies the central position among crops cultivated in Japan, but also because more than half the population of the world relies on rice. In view of the recent population explosion taking place on the global scale, many people fear that the supply of food grains will fail to meet the demand in the years to come. Population is growing at an extremely rapid rate in developing countries of the tropical or quasitropical areas of the world, where rice is the main food grain and where the shortage of food is already being keenly felt. In these areas efforts for an increase in the production of rice are considered the most essential prerequisite for fundamental solutions of almost all the problems prevalent there.

For the past several years, the Association of Japanese Agricultural Scientific Societies has sponsored a series of symposia on the theme of "rice in the world," as a forum for Japanese agricultural scientists to report on and discuss the results of on-the-spot investigations and researches on rice conducted in various parts of the world.

This document is a collection of reports on rice in Asia presented at these symposia. It is being published in English in the hope that these reports will prove useful as reference materials for those engaged in activities aiming at increasing rice production in Asian countries.

The credit for the original planning and implementation of the series of symposia is largely due to Dr. Yusuke Sumiki, former president of the Association, and Dr. Yasuo Kondo, former vice president of the Associa-

tion. On this occasion I would like to express my sincere gratitude for their efforts on behalf of the Association.

August, 1974

YUICHI OCHI  
President  
The Association of  
Japanese Agricultural Scientific Societies

# CONTENTS

**Introduction**.....TAKANE MATSUO

## I. RICE ENVIRONMENT AND CULTIVATION TECHNIQUES

**Meteorological Data in South-East Asia**....MORIO OCHIAI

1. Meteorological Data in South-East Asia ..... 11
2. Data Concerning South-East Asia as a Whole ..... 11
3. Data for Individual Countries ..... 15

**The Origin of Cultivated Rice and Its Adaptive**

**Evolution** .....HIKO-ICHI OKA

1. Origin of Cultivated Rice ..... 21
2. Differentiation into Indica and Japonica Types ..... 25
3. Adaptive Evolution of *sativa* Varieties ..... 27
4. Geographical Distribution of Rice Varieties ..... 30
5. Conclusions ..... 32

**Rice Production in South-East Asia and Some Nearby**

**Countries**.....NOBORU YAMADA

1. Rice Production in Afghanistan ..... 35
2. Rice Production in Ceylon (Sri Lanka) ..... 43
3. Rice Production in Indonesia ..... 54
4. Rice Production in the Republic of Korea ..... 65
5. Rice Production in Malaysia ..... 76
6. Rice Production in Pakistan ..... 90
7. Rice Production in Bangladesh ..... 99
8. Rice Production in the Philippines ..... 106
9. Rice Production in Taiwan ..... 117
10. Rice Production in Thailand..... 130
11. Rice Production in South Vietnam ..... 144

**Rice Culture in China**.....TAKANE MATSUO

1. Rice Culture in China ..... 157
2. History of Rice and Rice Culture in China ..... 160

3. Rice Environment in China .....	162
4. Kinds and Varieties of Rice .....	166

### **Technical Problems of Rice Production in Tropical Asia**

.....NOBORU YAMADA	
1. Irrigation and Drainage .....	170
2. Growing Season.....	174
3. Photoperiodic Sensitivity of Rice Varieties .....	177
4. Growing Duration.....	180
5. Fertilizer Response of Varieties.....	182
6. Yield Components.....	187
7. Plant Protection .....	190
8. Conclusions .....	190
Appendix: Technological Innovation in Asian Rice Production .....	191

### **Nutrio-Physiology of South-East Asian Rice**

.....AKIRA TANAKA	
1. Low Yield with Ample Application of Fertilizers .....	203
2. Low Yield due to Nutritional Disorders .....	206

### **Some Characteristics in Photosynthetic Activity of Leaves of Indica Rice Varieties.....AKIO OSADA**

1. Methods of Measuring Photosynthetic Activity of Leaves..	210
2. Light Intensity and Photosynthetic Activity of Leaves ...	211
3. Temperature and Photosynthetic Activity of Leaves ....	212
4. Changes in Photosynthetic Activity according to the Growth Stages.....	213
5. Varietal Differences in the Photosynthetic Activity of Leaves .....	216
6. Fertilizer Response, Photosynthesis and Respiration .....	218
7. Amount of Nitrogen Supply and Photosynthesis .....	219
8. Effect of Nitrogen Top-dressing on Photosynthetic Characters.....	220

## **II. IRRIGATION SYSTEMS AND WATER CONTROL**

### **Rice Cultivation and Water Balance in South-East Asia**

.....EIZO MARUYAMA	
1. Introduction.....	225
2. Computation of Water-Balance Factors .....	226
3. Suitable Period for Rice Cultivation Deduced from Water Balance .....	234
4. Agrometeorological Disasters .....	238

5. Water Requirement of Rice Plants.....	245
6. Conclusions .....	245

### **Irrigation Methods and Water Requirements in South-East**

<b>Asia</b> .....	YOSHICHI FUJIOKA
1. Introduction.....	248
2. Irrigation Systems .....	248
3. Water Requirements.....	250

### **Physiological Aspects of Water Control in the Cultivation of Indica Rice Varieties** .....

TOSHIO MURAKAMI

1. Mechanism of Consumption of Irrigation Water— Transpiration and Evaporation of Irrigation Water .....	252
2. Effects of Moisture Content of Soil on the Growth of Rice Plants .....	260
3. The Amount of Water Required for One Irrigation Operation and the Interval between Two Such Operations .....	270
4. Relationship between the Optimum Method of Irrigation and Other Conditions of Cultivation.....	271
5. Conclusions .....	274

### **Floating Rice, an Ecotype Adapted to Deep-water Paddies—**

#### **A Review from the Viewpoint of Breeding** .....

HIKO-ICHI OKA

1. Precipitation and Water Depth in Rice Fields .....	277
2. Response of Rice Ecotypes to Inundation .....	279
3. Culture Method of Floating Rice and Yield .....	282
4. Varietal Variation and Improvement of Floating Rice Varieties .....	284
5. Conclusions .....	286

### **Rice-Field Irrigation Systems in the Philippines**

..... YASUMITSU IENAGA

1. Introduction.....	288
2. Classification of Rice-Field Irrigation Systems in the Philippines.....	290
3. Rice-Production Patterns and Irrigation Communities in the Northern Mountainous Areas of Luzon Island and Central Luzon .....	291
4. Development of Irrigation Communities—"Traditional" and "Modern".....	294
5. Conclusions .....	301
Appendix: Irrigation Cost Problem in the National Irrigation System.....	302

## III. DISEASES, INSECTS, RATS AND WEEDS

**Epidemiology of Rice Diseases in South-East Asia** .....

YOSHIO HASHIOKA

1. Introduction ..... 311
2. Tropical Vernacular Diseases ..... 312
3. Prevalent Tropical Diseases ..... 313
4. Epidemic Diseases ..... 314
5. Sporadic Diseases ..... 315
6. Conclusions ..... 316

**Reaction of Rice Varieties to Major Races of *Pyricularia oryzae* in Asian Countries** .....

TAKUJI KOZAKA

1. Geographic Distribution of Pathogenic Races ..... 318
2. Reactions of Rice Varieties to Major Races in Asia ..... 321

**Bacterial Leaf Blight Disease of Rice in South-East Asian Countries** .....

SATOSHI WAKIMOTO

1. Distribution of BLB in South-East Asian Countries ..... 327
2. Strains of *X. oryzae* Collected from South-East Asia ..... 330
3. Resistance of Rice Varieties of Indica Type ..... 333
4. Ecology of the Pathogenic Bacteria in Tropical Rice Areas ..... 336
5. Forecasting Disease Occurrence in Tropical Areas ..... 336
6. Control of BLB in Tropical Areas ..... 337
7. Conclusions ..... 338

**Control of Bacterial Leaf Blight of Rice in South-East Asia** .....

SHOJI YOSHIMURA

1. Introduction ..... 340
  2. Characteristics of Bacterial Leaf Blight in South-East Asia ..... 340
  3. Seed Transmission ..... 342
  4. Utilization of Resistant Varieties and Its Effect ..... 343
  5. Control of Bacterial Leaf Blight ..... 345
  6. Countermeasures Against Wilt Disease (Kressek) ..... 345
  7. Chemical Control Tests in Sri Lanka ..... 347
  8. Development of New Chemicals ..... 348
  9. Conclusions ..... 350
- Appendix

**Breeding for Resistance to Rice Virus Diseases in South-East Asia and Japan** .....

KUNIO TORIYAMA

1. Tungro ..... 354
2. Grassy Stunt ..... 356



3. Transitory Yellowing .....	357
4. Orange Leaf .....	357
5. Stripe .....	357
6. Black-streaked Dwarf .....	359
7. Yellow Dwarf .....	359
8. Dwarf .....	360
9. Necrotic Mosaic .....	361
10. Conclusions .....	361
 <b>Present Status of Chemical Control of Rice Plant Diseases</b>	
<b>in South-East Asia .....</b>	<b>YOSHITERU KUMAMOTO</b>
1. Rice Blast ( <i>Pyricularia oryzae</i> ) .....	363
2. Relation between Species of Rice and Blast .....	363
3. Weather Conditions and Rice Blast .....	364
4. Relation between Fertilizer and Blast .....	365
5. The Control of Blast Diseases .....	366
6. Other Diseases .....	367
 <b>Field Rat Problems in South-East Asia ..</b>	
<b>MASAMI MOCHIZUKI</b>	
1. Damage Due to Field Rats .....	369
2. Principal Species of Field Rats and Distribution .....	371
3. Habitat and Environment .....	375
4. Ecology and Rat Damage .....	377
5. Extermination Methods .....	379
6. Extermination Targets .....	381
 <b>Insects Injurious to Rice Cultivation and Their Natural</b>	
<b>Enemies in South-East Asia .....</b>	<b>KEIZO YASUMATSU</b>
1. Significance of Natural Enemies .....	389
2. Feasibility of Utilizing Natural Enemies as Controlling Agents of Rice-Stem Borers .....	391
 <b>Insect Pests of Rice and Suitable Insecticides for South-East</b>	
<b>Asian Countries .....</b>	<b>NAOKI HATAI</b>
1. Major Insect Pests of Rice .....	393
2. Control of Insect Pests in Each Country .....	395
 <b>Application of Insecticides for the Control of Stem Borers</b>	
<b>in South-East Asia .....</b>	<b>TETSUO SAITO</b>
 <b>Present Status and Prospects for Pesticide Use in Rice</b>	
<b>Cultivation in South-East Asia .....</b>	<b>HIDETSUGU ISHIKURA</b>
1. Rice Protection and the Need for Pesticides .....	412
2. Rice Pest Control and the Use of Pesticides in Several Countries .....	417

3. Future Prospects for Pesticide Use for Rice Protection in South-East Asia ..... 429
4. Conclusions ..... 435

**Weed Control and Herbicides in Rice Culture** .....  
 .....SHOOICHI MATSUNAKA

1. Introduction ..... 438
2. Weeds in Rice Culture ..... 438
3. Weed Damage to Rice ..... 441
4. Weed Control Methods Other than Chemical ..... 444
5. Chemical Weeding in Rice Culture (Utility of Herbicides) 447
6. Economic Problems of Herbicides ..... 450
7. Safe Use of Herbicides ..... 452
8. Conclusions ..... 455

#### IV. PRESENT STATUS OF MECHANIZATION

**The Present State and Problems of the Mechanization of Rice Farming in South-East Asia** ..... SABURO NIIZEKI

1. Outline of Natural Conditions ..... 461
2. Various Techniques to be Adopted for Mechanization in Rice Farming ..... 462
3. Conclusions ..... 468

**Some Problems of the Adaptability of Japanese-made Agricultural Machinery in Asian Countries** .... HIROYUKI SHIMODA

1. Introduction ..... 470
2. Some Problems of Land Preparation on Wet Paddy Fields 470
3. Weeding and Crop Protection Equipment ..... 475
4. Some Problems in Harvesting, Threshing and Rice Processing Operations ..... 476
5. Other Machines for Paddy Cultivation ..... 477
6. Conclusions ..... 478

#### V. HARVESTING, MILLING, AND STORAGE

**Present Status and Problems of Rice-Processing Procedures from Harvesting through Milling in South-East Asia—A Case Study on Indonesia** ..... TOSHIZO BAN

1. Introduction ..... 483
2. Present Status and Problems of Harvesting ..... 484
3. Present Status and Problems of Threshing ..... 485
4. Present Status and Problems of Milling and Rice Mills ... 486

**Current Status and Problems of Rice-Processing Procedures from Harvesting through Milling in South-East Asia — A Case Study on Malaysia** ..... RITSUYA YAMASHITA

1. Introduction ..... 495
2. Climatic Conditions to be Taken into Account in Harvesting, Drying and Storing Paddy Grains ..... 496
3. Harvesting and Sieving ..... 504
4. Drying Work ..... 505
5. Hulling and Milling ..... 512

**General Status of Rice Storage in South-East Asia**

..... TATSUO TANI

1. Causes of Waste and Losses during Rice Storage ..... 514
2. General Status of Rice Storage ..... 515
3. Storage Facilities ..... 518
4. Control Measures of Damage during Storage ..... 519
5. Changes of Rice Quality during Storage in Tropical Climates ..... 520
6. Need for Improvement of Rice Storage Procedures ..... 522

**Storage of Rice Grains and Pest Control, with Special Reference to Sri Lanka and India** ..... NOBORU KAWAMOTO

1. Introduction ..... 523
2. Storage Methods and Rice Pest Control in Sri Lanka ..... 523
3. Effect of Chemical Control ..... 533
4. Stored Grain Pests and Chemical Control in India ..... 533
5. Stored Grain Insects Intercepted on Rice from South-East Asia ..... 533
6. Discussion ..... 534

**Quality of Rice in South-East Asia** ..... SHINJIRO CHIKUBU

1. Appearance and Shape ..... 537
2. Cooking Quality and Edibility ..... 540

**Utilization of Rice-Bran for Oil Making in South-East Asia**

..... KENZO YOKOCHI

1. Development of the Rice-Bran Oil Industry in Burma .... 551
2. Development of the Rice-Bran Oil Industry in Thailand .. 554
3. Development of the Rice-Bran Oil Industry in India .... 556
4. Development of the Rice-Bran Oil Industry in Nepal .... 557
5. Development of the Rice-Bran Oil Industry in Taiwan ... 561
6. Development of the Rice-Bran Oil Industry in Republic of Korea ..... 562

7. Conclusions .....	563
----------------------	-----

## VI. DISTRIBUTION AND MARKETING

### **Production and Trade of Rice in Egypt . . . . SUSUMU ISHIDA**

1. Production of Rice in Egypt .....	567
2. Trade in Egyptian Rice .....	567
3. Some Problems in Production and Trade of Egyptian Rice .....	571

### **Production, Trade and Marketing of Rice in South-East Asia —Basic Characteristics of Demand and Production of Rice in South-East Asia . . . . . TAKESHI MOTOOKA**

1. Introduction .....	575
2. The Changing Situation of Rice Production, Trade and Prices in the Last Decade in South-East Asia .....	576
3. The Present Rice Situation in South-East Asia .....	584
4. Prospects for Rice in South-East Asia .....	587
5. Marketing of Rice in South-East Asia .....	589

### **Some Aspects of Rice Marketing in India .....** ..... HACHIRO FUKUZAWA

1. Measures for the Improvement of Traditional Marketing Organizations .....	595
2. Rice Procurement and Distribution Policies .....	595

### **Impact of the Green Revolution on World Trade in Rice ..... KENZO HEMMI**

1. Introduction .....	598
2. Technology and the Green Revolution .....	599
3. Policy and the Green Revolution .....	599
4. Conclusions .....	600

# RICE IN ASIA

Edited by

THE ASSOCIATION OF  
JAPANESE AGRICULTURAL  
SCIENTIFIC SOCIETIES

UNIVERSITY OF TOKYO PRESS



## Introduction

TAKANE MATSUO

*Faculty of Agriculture, Tamagawa University, Tokyo, Japan*

---

Rice is the greatest food plant in the world. Most peoples in Asia and many other tropical and subtropical countries live on rice.

Almost all cultivated rice plants belong to *Oryza sativa* L. which originated in Asia. They are divided roughly into two subspecies, Indica and Japonica.

Indica is adapted to the tropical zone and Japonica has evolved for the temperate zone. Between these two typical subspecies, rice has differentiated into many kinds of ecotypes according to local conditions. Each ecotype has a different response to day length, temperature, soil fertility or water supply. Accordingly, different ecotypes of rice are cultivated corresponding to differences in paddy fields, growth seasons, and/or methods of cultivation.

In general, Indica rice is mainly grown in tropical and subtropical zones and Japonica rice is cultivated in mountainous regions and temperate zones. Recently, improved varieties which have been bred by selection and hybridization at the International Rice Research Institute and agricultural experimental stations in various countries are being introduced more widely. Improved varieties give high yields when field conditions are well-controlled and high-level culture techniques including fertilizer application and pest control are used. However, rice culture conditions in South-East Asia are not always well-controlled.

Rice culture in Asia is mainly done with the aid of natural precipitation in the monsoon season. Though irrigation facilities for rice culture exist in some temperate regions and a part of the tropical zone, most rice culture in South-East Asia is regulated by natural precipitation. Thus, rice growth in this area is unstable and the average yield of rice per unit area is generally low.

Recently, rice yields in some parts of south-east Asia have gradually increased due to the introduction of improved varieties and application of chemical fertilizers. On the other hand, however, in proportion to the application of chemical fertilizers, insects and diseases have gradually increased too. Uncontrolled application of pesticides may cause environmental hazards in these areas. Methods of pest control suitable for the ecological conditions in tropical rice culture should be applied on the basis of investigations of rice physiology and the local ecology of insects and diseases.

Rice is a staple food in Japan. Paddy fields are distributed over all Japan. However, because Japan is located at the northern limit for rice growth, rice culture frequently suffered due to low temperature and pests. Rice yield in the past was poor and unstable due to the weather conditions.

Since 1894, Japan imported rice for long time due to the increasing population after the Meiji Restoration in 1868. Therefore, research on rice production, such as land improvement, rice breeding, culture techniques, etc., have been carried out in this country. As a result, rice yield per unit area has gradually increased and stabilized.

Besides technical improvements in rice culture, the policy of land reform and the price-guarantee system for rice production have increased rice production considerably. Self-sufficiency in rice was attained in Japan by 1955. Since then, rice production has surpassed the indigenous demand due to the decreasing rice consumption per head.

Self-sufficiency in rice has played an important role in the economic reconstruction of Japan after World War II.

On the other hand, however, rice and paddy fields have become badly polluted, and the human environment in Japan has been degraded by the excess application of chemical fertilizers and pesticides to rice. In the face of such environmental problems Japanese scientists have started to seek new techniques for rice culture which are harmless to the environment under high-yield conditions.

Recently, a number of Japanese experts on rice culture have visited many rice-growing countries in the world. Some of them, in the course of technical aid from the Japanese Government or FAO to the developing countries, have investigated rice and rice culture in south-east Asia, collaborating with local scientists.

The Association of Japanese Agricultural Scientific Societies (AJASS) has held symposia on "Rice in the World" and collected the results of these investigations. The symposia were expected to give some suggestions for the improvement of rice culture in Japan and to contribute to the advance of rice cultivation throughout the world.

Symposia were held 10 times during the 7 years from 1966 to 1972.



Subjects and topics presented by the speakers are listed at the end of this article.

The Symposia Committee for "Rice in the World" was organized in the AJASS for planning, arrangement and management of the symposia. Each member of the Committee was the chairman of a subcommittee in each participating society.

Members of the Committee are as follows:

Takane Matsuo (Vice President of the AJASS), Chairman  
Masaki Horie (Japanese Society of Breeding)  
Shin-ichi Takagi (Japanese Society of Applied Entomology and Zoology)  
Yasuo Ohta (Crop Science Society of Japan)  
Takeyuki Mizukami (Phytopathological Society of Japan)  
Ryohachiro Nakamura (Japanese Society of Zootechnical Science)  
Keizaburo Kawaguchi (Society of the Science of Soil and Manure, Japan)  
Yukio Ozawa (Society of Agricultural Meteorology of Japan)  
Kenzo Henmi (Agricultural Economic Society of Japan)  
Saburo Tamura (Agricultural Chemical Society of Japan)  
Toshio Yawata (Japanese Society of Irrigation, Drainage and Reclamation Engineering)  
Isamu Yamanaka (Society of Agricultural Machinery, Japan)

This book contains papers presented in the symposia, selected from topics concerned with rice culture in Asia. Editing has been done by the Committee. The Committee is grateful to Prof. I. Yamanaka for collecting and arranging the manuscripts in this book.

#### Symposia on "Rice in the World"

(held in 1966-1972)

1. The First Preparatory Symposium: "General Problems of Rice Culture in the World" (on 29 Nov. 1966)
  - 1) Rice Culture and Damage to Rice Caused by Insect Pests (by H. Ishikura)
  - 2) The Present Status and Problems of the Mechanization of the Rice Farming in South-East Asia (by S. Niizeki)
  - 3) Rice Production in South-East Asia and Some Nearby Countries (by N. Yamada)
  - 4) Studies on Methods of Fertilizer Application on Rice in South-East Asia (by S. Nishigaki)
  - 5) Water Utilization for Rice Culture in South-East Asia (by K. Takeda)