PROCEEDINGS

Rice Technical Working Group

June 29 - - July 1, 1960, Lafayette, Louisiana

Agricultural Experiment Stations of

Arkansas, California, Louisiana, Mississippi and Texas

and the

Agricultural Research Service, U. S. Department of Agriculture

CONTENTS

[1]The following abstracts were not available for publication:
Current Status of Hoja Blanca and its Vector in the United States, R. N. Dopson, Jr.
Effects of Milling Rice at Low Moisture Levels, F. T. Wratten

(These Proceedings were compiled by H. M. Beachell, secretary, Rice Technical Working Group)

ORGANIZATION AND PURPOSE OF THE RICE TECHNICAL WORKING GROUP

The Rice Technical Working Group functions pursuant to an informal memorandum of understanding among the state agricultural experiment stations and agricultural extension services of Arkansas, California, Louisiana, Mississippi and Texas, and the Agricultural Research Service, Agricultural Marketing Service and Federal Extension Service of the United States Department of Agriculture. Its membership is composed of personnel in each of these agencies who are actively engaged in rice research and extension investigations. Participants from the states are designated by the directors of the state experiment stations and extension services concerned. USDA representatives are designated by the service or branch concerned with rice research and extension. An administrative advisor is elected jointly by the experiment station and extension service directors.

Officers of the group consist of a chairman and a secretary elected by the membership. Interim affairs are handled by an executive committee consisting of the elected officers, administrative advisor, executive secretary of tht USDA Rice Research and Marketing Advisory Committee, and two elected members, one of whom is an active research worker on rice in a state agricultural experiment station and the other an active state agricultural extension worker on rice.

The Rice Technical Working Group meets at least biennially to provide for the continuing exchange of information, cooperative planning and periodic review of all phases of rice research and extension being carried on by the states and the federal government. It develops proposals for future work which are suggested to the participating agencies for implementation.

This Working Group had its origin in a conference of state and federal agencies at Beaumont, Texas, in 1949, on drying and storage of rough rice.

Conditioning and Storage Data Published

The comprehensive report, "Research on Conditioning and Storage of Rough and Milled Rice," was published as ARS Report No. 20-7, dated November 1959.

The Rice Research and Marketing Advisory Committee, in their 15th annual report and recommendations, dated December 1959, recognized the completion of this report with the following statement: "The Committee commends the many federal and state researchers and specifically the arranger and editor, W. C. Dachtler, for the comprehensive review of 'Research on Conditioning and Storage of Rough and Milled Rice,' published as ARS Report No. 20-7, November 1959. This tangible accomplishment of the Rice Technical Working Group is a thorough analysis of the existing published and unpublished research on conditioning, storage and preservation of quality of rice. It provides a valuable source of information to all handlers and processors of rice as well as to researchers and teachers. It also highlights problems meriting further study and should effectively reduce unnecessary duplication and repitition in future studies of rice conditioning and storage."

Dates and Place of 1960 Meeting

The ninth annual meeting was held June 29 to July 1, 1960, in Lafayette, Louisiana, at the First National Bank Civic Room. Officers in charge of the meeting were: Dwight C Finfrock, chairman; H. M. Beachell, secretary; R. J. Hodges, Jr., extension service representative; Francis J. Williams, experiment station representative; and R. D. Lewis and W. C. Dachtler, administrative advisors.

Uniform System of Reporting Yields

The Rice Technical Working Group voted in favor of a uniform unit of measure in expressing acre and mill yields of rice. In the past, acre yields have been reported in barrels, bushels, hundredweight and pounds. At future meetings the group voted to report grain yields in pounds of rough rice per acre and mill yields in percentages, and urged state and federal agencies to do likewise in their reports and publications.

Officers Elected

Newly elected officers to serve for the next 2 years are: *chairman*: H. M. Beachell, Rice-Pasture Experiment Station, Beaumont, Texas; *secretary*: Francis J. Williams, Rice Branch Experiment Station, Stuttgart, Arkansas; *state experiment station representative*: R. J. Miears, Rice Experiment Station, Crowley, Louisiana; *state extension service representative*: M. D. Miller, University of California, Davis California; and *administrative advisors*: R. D. Lewis, Director, Texas Agricultural Experiment Station, College Station, Texas, and W. C. Dachtler, Executive Secretary, USDA Rice Research and Marketing Advisory Committee, Washington 25, D. C.

Dates and Place of 1962 Meeting

The next meeting of the Rice Technical Working Group will be held in 1962 in Houston, Texas. The exact time and place will be determined by the executive committee, but the group favored February.

RECOMMENDATIONS OF THE PANEL ON RICE BREEDING AND GENETICS

N. E. Jodon, Leader
M. T. Henderson
C. N. Bollich
H. R. Caffey
John Scott
T. H. Johnston
James Stansel
J. R. Thysell

Because of the demands imposed by the many and changing conditions under which rice is grown, varieties of the three grain types need to be improved in the following respects: 1. resistance to diseases, especially blast (Piricularia) and hoja blanca; 2. resistance to lodging; 3. efficiency in the utilization of heavy applications of fertilizer; 4. milling, processing and cooking characteristics and nutritive value; 5. cold hardiness at all stages of growth; 6. seedling emergence and plant vigor; 7, resistance to insects; 8. salt and alkali (high pH) tolerance; 9. production of a second or "stubble" crop; and 10. tolerance to pesticides.

To accomplish the foregoing aims, more emphasis must be placed on basic research carried out in close cooperation among the breeders and specialists in the fields of pathology, agronomy, physiology, soil science, cereal chemistry, entomology, genetics and cytogenetics and morphology.

Phases of the program needing specific attention to accomplish these objectives are:

Genetics and Cytogenetics

Genetics and cytogenetic studies should be given increased emphasis and support because the principles involved are fundamental to the achievement of all rice breeding objectives. Information is needed especially on the mode of inheritance of complex characters of economic importance and on the linkage relationship of genetic characters.

Cold-hardiness

More emphasis is needed on basic studies of cold water tolerance at all stages of plant growth. Controlled temperature screening should be continued to determine which varieties have sufficient hardiness for use in breeding for tolerance to cold water and other low temperature conditions.

It is recognized that rice breeders are responsible for making available information on varieties and for maintaining breeders' seed of recommended varieties originated and recommended by state and federal agencies.

Disease Resistance

In cooperation with the pathologists, expand the breeding and testing program for the development of adapted varieties of the three grain types resistant to blast (Piricularia). Proceed with intensified breeding programs leading to the further development at the earliest possible date of hoja blanca-resistant short, medium and long-grain varieties adapted to the major rice-producing areas of the United States. Continue the close cooperation with entomologists and pathologists in developing improved methods of testing, in the seedling stage, for resistance to hoja blanca.

Lodging Resistance

Investigations of the several factors relating to lodging resistance, including basic research on morphology and nutrition of the rice plant, need to be conducted.

Fertilizer Response

Studies to determine the response of varieties to high levels of fertilization should be expanded. The response of individual varieties to various timing of nitrogen applications should be studied in relation to lodging. Varieties should be developed that will resist lodging and produce high grain and mill yields when high rates of fertilization are used.

Yield Components

Basic studies on the components of grain yield are needed to afford a more realistic basis for selection by the breeder.

Processing and Cooking Characteristics

The need for adapted varieties of rice possessing specific processing and cooking characteristics, to meet domestic and foreign market demands, is increasing in importance. Continued improvement in tests for basic quality evaluation is needed for the development of such varieties.

RECOMMENDATIONS OF THE PANEL ON PROCESSING, COMPOSITION AND NUTRITION

H. J. Deobald, Leader
E. A. Fieger
J. T. Hogan
A. S. Roseman
M. C. Kik
M. Isabel Irwin
T. J. Canavan
E. B. Kester
Daniel R. Sidoti
Virginia Williams
E. C. Hagberg
K. K. Keneaster
John V. Halick
Leo Amhrein

The panel feels that fundamental research on rice should be encouraged and expanded. Research is needed to elucidate certain complex phenomena characteristic of the starch granule, such as gelatinization, retrogradation, alkali dispersibility and internal structure. As these phenomena are clarified, the complex process known as cooking, and the changes resulting therefrom, can be descrided more thoroughly.

It is necessary to determine what substances in addition to amylose and amylopectin in the starch matrix affect the characteristics of rice. Knowledge of the influence of protein and protein fractions, pectins, hemicelluloses, celluloses, lipids and other minor constituents in the starch matrix on the behavior of rice is practically nonexistent. Many problems remain in developing techniques to isolate and purify these component parts for detailed study. In addition to the tangible properties outlined, the sensory properties of rice, such as flavor components and "mouth appeal," should be determined objectively with newer techniques.

The panel takes note of the accumulated wealth of published data on rice chemistry existing in other countries of the world today, Japan in particular. This material, if translated and made available to researchers in this country, would be a valuable aid in attacking these problems. The panel feels that this material could be translated at little cost to the U. S. taxpayer by making use of P.L. 480 funds, and it recommends that the proper agencies begin the procedure required to implement this action where such funds may be available.

It is recommended that work be expanded to improve existing testing procedures and to develop new methods for measuring the properties and constituents of rice. The panel recognized that standard objective testing methods are needed that will be acceptable and reproducible in qualified laboratories.

Research to develop new products and processes and to improve present processing techniques should be expanded. Such research should seek industrial uses continuously, as in fiber, plastics or as a processing adjunct or aid in other industries, as well as new and improved food products.

Developmental work to improve brown rice, rice bran and the nutritional value of milled white rice by the addition of food supplements and treatment to improve the acceptability of rice to foreign as well as to domestic consumers, were some of the projects suggested.

The panel recognizes that the research outlined here is more extensive than present personnel could hope to cover adequately in the near future. It was desired, however, to point out the broad areas of potentially profitable fields of research open to immediate investigation.

RECOMMENDATIONS OF THE PANEL ON RICE DISEASES

John G. Atkins, Leader
H. A. Lamey
G. D. Lindberg
G. T. Templeton

Important advances have been made in recent years on rice diseases through basic and applied research. The relative importance of certain diseases has shifted. Several diseases deserve continual research.

Hoja Blanca

Intensive studies should be continued on the hoja blanca disease of rice. It is recommended that the program be continued even in the event the disease and vector are not found in the U. S. in 1960. While good progress has been made on certain phases of the hoja blanca research program, research objectives have not been achieved on all phases. Studies to be continued are testing rice selections for resistance, in cooperation with the rice breeders, along with studies on the nature and inheritance of resistance. Also to be continued are studies on host range, movement of the virus in the plant, influence of temperature, light, fertilization and other factors on disease development, histological changes induced by the virus and the basic causes of sterility. Since present greenhouse testing techniques are not ideal, improvements should be made in cooperation with the entomologists. Surveys as to the distribution of the disease and vector, *Sogata orizicola*, in the U. S. rice area should be continued in cooperation with other agencies.

Blast

Considerable progress has been made on a recently initiated blast research program. Studies need to be continued on the distribution and prevalence of the races of *Piricularia oryzae* in the southern rice states and the reaction of the rice varieties to each race. Emphasis should be placed on the field and greenhouse testing of rice selections, in cooperation with the rice breeders, for the development of blast-resistant varieties and on the nature and inheritance of resistance. Other studies should be the influence of atmospheric moisture, fertilizers and temperatures on disease development and control by fungicides.

Kernel Smut

The life history of kernel smut is unknown, particularly as to the site of infection. When the studies show how and where infection occurs, rice varieties can be tested for resistance or other control measures may be effective.

Helminthosporium Leaf Spot

Present work on developing resistant varieties should be continued, in cooperation with the rice breeders. The role of nitrogen fertilization could be studied.

Straighthead

A need still exists for the testing of new selections from the rice breeding program for straighthead reaction.

Stem Rot

Better methods are desired for testing rice varieties and selections for stem rot reaction. The present testing program should be continued.

Seed-treatment Chemicals

Additional fungicides should be tested on drill and water-seeded rice. Tests on the compatibility of fungicides and insecticides should be continued.

"Panicle Blight"

Several rice varieties frequently show a panicle and spikelet blight of which the cause is unknown. The several associated fungi should be tested as possible causes of this condition.

It is recommended that we attempt to achieve a balance between basic and applied research in the rice disease program.

RECOMMENDATIONS OF THE PANEL ON INSECT CONTROL

L. D. Newsom, Leader
C. C. Bowling
W. W. McMillian
H. L. Alford
J. L. Cowger
L. H. Rolston
A. H. Siddiqi
J. U. McGuire, Jr.

Field Insects

Specific research needs to be done to evaluate effects on yield and grade of infestations by the rice stink bug, rice water weevil, grape colaspis, rice leaf miner, grasshopper, leafhopper and other insects which may be of economic importance. It also is recommended that studies of the biology, ecology and possible effectiveness of biological control measures of these insects be given high priority. Continuing cooperative surveys of rice field insects in the United States should be conducted with emphasis on the vector of hoja blanca. Testing of present insecticides and screening of new materials should be continued in the over-all program of rice insect pest control to develop more effective control measures and to alleviate the residue problem. Special attention should be devoted to developing more efficient and less phytotoxic seed treatments. Work should be expanded on cultural control of rice field insects.

Storage Insects

Develop and improve methods for the prevention of insects in both commercial and on-the-farm storage by sanitation, aeration and protective materials. More study needs to be made on the behavior of insects as related to migration and improvement of present methods and materials and the development of new methods in the control of insects in stored rice. Special emphasis should be placed on the development of dosages for fumigants and other chemicals to stay within residue tolerances.

RECOMMENDATIONS OF THE PANEL ON CULTURAL PRACTICES, SOILS AND PHYSIOLOGY

Francis Williams, Leader
Douglas Ormrod
Vernon Hall
Dwight Finfrock
L. E. Crane
Roy J. Smith
Kenneth Viste
John Baker
Harry Hudgins
Austin Harrell
Nathan Evatt
R. J. Miears

Cultural Practices

The committee recognizes that the many cultural practices followed in the production of rice influence the use made of this food grain, and urges greater emphasis be placed on those factors affecting the production of a high quality product that can be marketed and utilized by the customer.

To meet the many changing conditions facing rice production, future research should include the following studies:

1. Work should continue on length and type of rotation, time and methods of tillage, relative efficiency of fertilizer materials, methods of applications of fertilizers, interaction of fertilizer treatments with weeds, grass and insect control and the effects of crop residues and their decomposition products on seedling stands and yields.

2. There is a need for continued study of differences among varieties in response to fertilization. Outlying fertilizer experiments should continue to cover a wide range of soil conditions and crop existence, and should include soil test correlations to serve as a basis for more accurate recommendations in individual fields.

3. Additional research is needed on the use of new crops and their rotations with rice to diversify farming systems in the rice-growing areas of the United States.

4. Fundamental research should be continued on the physiology of the rice plant. Factors existing in submerged soils, photoperiodism, temperature relations, mineral nutrition, biotic relationships and the environment-rice variety interactions should be studied in relation to the growth and fruiting behavior of rice.

It is evident that such fundamental research will be necessary for continued progress in producing quality rice at the lowest unit production costs.

It is recommended that adequate personnel be maintained to work in this research area and that suitable controlled environment growth facilities be provided.

5. Water management in relation to stand establishment, weed control, fertilizer practices, plastic materials for rice field levees and water quality and temperature, should continue to receive research attention.

6. The possibilities of using better or new management practices in producing a ratoon, or second rice crop should be continued. Research should include irrigation, fertilization, crop management, new varieties which may be used to increase the value of the second crop, and the over-all efficiency of rice production.

7. Coordination of research done under the Fulbright Bill (rice-fish farming research legislation) should include representatives of personnel involved in agronomic aspects of rice-fish farming.

8. Recognizing that these problems include many fields of specialization and that any given problem might influence the results of another study, it is recommended that cooperative research be stressed and encouraged.

9. This committee further emphasizes that the more pertinent results of research within this field be exchanged among the workers and be released to farmers and other interested parties more rapidly than in the past.

Weed Control

Realizing that, whenever possible, weeds in rice fields should be controlled by good cultural practices, such as early plowing, subsequent disking of weeds, water planting and wise watering practices combined with proper time of application of fertilizers, the following recommendations are made:

1. That further investigations be conducted on the evaluation of the new chemicals in controlling broad-leaved weeds, giving special consideration to the injury of the rice and adjoining crops.

2. That studies continue to be made on chemical control of grasses by direct application of chemicals as pre-planting, pre-emergence and post-emergence treatments, and by the use of chemicals in conjunction with other cultural practices.

3. That investigations be made on the effect of continuous use of herbicides and rotating herbicides in various single-crop and rotating-crop situations on the ecology of weeds and on the growth and yield of rice.

4. Additional work should be done on the control of algae in rice fields and the control of weeds in irrigation and drainage ditches.

5. More work should be done on the life history of the principal rice weeds to determine the place in their life cycles at which most effective control might be applied.

6. That state and federal regulatory laws on the use in rice of phenoxy-type herbicides and desiccants be reviewed and standardized in relation to research resulting according to rate, formulation and time of application of the chemical.

7. That economic information be obtained on losses in rice yields and quality due to weeds. The effects of the number and duration of infestation of various weed species on yield and quality should be investigated.

Agricultural Equipment

Aircraft. Expand new work on the development and improvement of equipment and methods for air application of herbicides, fertilizers and seed as applied to rice. Weeds in rice fields cause fields to be abandoned before harvest, and the presence of weed fragments makes the drying and storage of rice difficult and expensive. While it is now common practice to sow rice with airplanes, the need for more even distribution still exists. The application of fertilizers by air also could become more widespread with better distribution equipment.

Ground Equipment. Improved cultural practices in rice production have made certain existing farm implements partially obsolete. Research on the modification and the new design of existing equipment is necessary if farmers are to profit from the better practices. Equipment is needed particularly for precision seeding and simultaneous fertilizer placement. New fertilizer placement equipment is needed particularly in rice culture.

RECOMMENDATIONS OF THE PANEL ON DRYING AND STORAGE

Reed S. Hutchison, Leader
Joseph T. Hogan
E. B. Kester
Harold A. Kramer
Xzin McNeal
Carter Price
Job K. Savage
H. W. Schroeder
Harlan Traylor
Elvin W. Tilton
Theodore Wasserman

1. That studies to determine the nature and causes of so-called "heat damage" be continued.

2. That dosages of fumigants and/or grain protectants and techniques, including air movement, that will be effective for the treatment of rough and milled rice without leaving residues greater than the prescribed tolerances, be studied and developed further.

3. That research be continued to determine the effects of aeration on stored rice other than the effects on temperature and moisture content.

4. That an evaluation be made of present work and findings on the effects of temperature in stored rice on the reproductive potential of insects, and that needed new work be initiated.

5. That studies be initiated to determine the behavior of rice stored under inert gas and gaseous atmospheres of special composition.

6. That studies be continued on the relationship of rice moisture content to milling, storage and cooking characteristics, consideration also being given to raising the moisture of the rice after milling.

7. That a study be made to develop objective means for measuring the degree of milling, chalkiness, peckiness and other grade factors.

8. That a re-evaluation be made of physical properties of rice, such as the static pressure characteristics, angle of repose and true and apparent densities of different moisture content rices.

9. That present information on physical and chemical constants be brought up to date and published as a handbook for the rice industry.

10. That further study be made on the effects of varietal differences in their response to drying and storage.

11. That the microbiological aspects of rice storage in relation to cooking and processing characteristics and deterioration, other than that known as "heat damage," be continued and expanded.

12. That the field of storing milled rice be explored and extended if necessary.

13. That a study be made of the possibility of off-season use of rice drying and storage facilities for conditioning and storing of forage crops.

14. That new methods, techniques and equipment for drying rice be investigated.

15. That studies be continued on the time-temperature-moisture relationship in drying rice.

16. That a study be initiated on new methods, techniques and equipment for milling rice.

17. That head yields of rice be expressed in percentage for research reports.

18. That economic considerations be applied to the data obtained from all studies mentioned.

19. That work be initiated toward the developing of improved methods, techniques and equipment for sampling rough and milled rice.

RECOMMENDATIONS OF THE PANEL ON ECONOMICS AND MARKETING

Troy Mullins, Leader
L. B. Ellis
R. E. Post
Carter Price
J. K. Savage
N. Thuroczy
H. Traylor

The following recommendations pertain to production economics, drying and storage, marketing and related activities.

1. Routine work of summarizing data on production requirements and costs for rice and competing enterprises by major production areas should be continued. Such information is basic to the development of sound education and policy-oriented programs.

2. Information concerning individual enterprises, or specific production techniques, must be examined from the standpoint of practical management systems which, when applied by farmers, would produce optimum returns from resources used in the production process. A close working relationship among technicians in the various fields is essential in deriving the optimum management systems for each area.

3. Research should be initiated to determine, by individual production areas and for the United States as a whole, the total amount of resources that would be used for growing rice, and the aggregate production that would result when the factors controlling the decision of farmers are related primarily to profit or income from the different enterprises. These basic conditions are: (a) no acreage controls are in effect, (b) prices received for rice considered at present, and at substantially lower and higher levels, and (c) when technology is at present and at substantially advanced levels.

4. Extend economic studies on the drying and storage of rough rice to determine the cause of the higher costs and risks of some farm and commercial drying and storage facilities, and to develop new and improved methods and equipment to increase the efficiency of this operation.

5. The committee recognizes the need for continued research in the field of foreign markets in line with the recommendations made at the latest meeting of the Rice Technical Working Group (Recommendations 1 and 2 of the Marketing Section).

6. With a view of increasing the aggregate rice consumption in the United States, a national study be undertaken to ascertain the demand for rice among different consumption and income groups, including the demand for substitute commodities.

7. Further efforts should be made to explore the possibilities of expanding the domestic market for rice, such as the introduction of foreign rice and products.

RECOMMENDATIONS OF THE PANEL ON EDUCATION AND EXTENSION

R. J. Hodges, Jr., Leader
Ruel P. Nester
Lewis Hill

1. Improvement continue to be made by the Agricultural Extension Service in bringing new research developments to the nation's rice farmers. State and county extension workers should be encouraged to continue effective dissemination of rice research findings. We recommend the continued inter-change of information between research and extension personnel.

2. There continues to be a need for all current information pertaining to economic and legislative changes influencing the rice industry. The panel suggests that the responsibility for collecting this information be assigned to the Federal Extension Service. This procedure would permit the information to be available to each production specialist before it is released to the general public.

3. We request that Federal Extension Service personnel, and particularly utilization specialists, increase their use of newsletter and other media to make available current developments and research results of interest to their respective state and county counterparts.

4. We urge that rice research workers continue to summarize and publish research findings promptly so that this information may be incorporated more quickly into the information program. Extension should continue rewriting this material in popular-type publications as it becomes available.

5. We recommend that a committee on bibliographies and translations be considered to establish a central library on rice research. This library should contain U.S. publications on rice and pertinent publications from other countries, with translations when necessary.

6. There is much misunderstanding and confusion concerning the responsibility of agricultural workers and producers regarding details of regulations governing the use of certain pesticides. Immediate information is needed to insure compliance with Public Law 518 and subsequent ammendments as related to recommendations for applications of 2-4-D and other chemicals used to control weeds in rice.

Breeding and Genetics Section

M. T. Henderson, Moderator

Objectives of the Rice Improvement Program

C. Roy Adair*

Rice breeding investigations have been conducted by the U. S. Department of Agriculture in cooperation with the agricultural experiment stations in the rice-producing states during the past 60 years. At first these studies were confined to the introduction and testing of varieties from foreign countries in an effort to find types that would produce economic yields in the South and in California. Several varieties were selected from these early introductions. Some of these are: Fortuna, Rexoro, Nira, Acadia, Wataribune, Butte, Colusa and Caloro. The early introductions were made available to farmers, and from this material one farmer-breeder selected Blue Rose, Early Prolific, Edith and Lady Wright.

It soon became evident that it would not be possible to obtain the desired types by selecting from the introductions, so about 1920 the hybridization method of breeding was initiated. This increased the variability of the breeding material and made it possible for the breeders to obtain combinations of characters not available in existing varieties. Some of the varieties developed by this method are Bluebonnet, Texas Patna, TP49, Lacrosse, Nato, Toro, Century Patna 231 and Arkrose. Irradiation has been used in recent years in an attempt to increase variability and to obtain mutations not known or only rarely available. The backcross method has been used to some extent in recent years. Calrose was developed by this method of breeding. This method is being used to develop hoja-blanca-resistant types.

The general objectives of the rice breeding program are to develop short, medium and long-grain varieties that are resistant to diseases, insects and lodging; hardy in respect to water and soil temperature during the periods of germination and emergence in the spring and flowering and maturation in the fall; possess the desired processing and cooking characteristics to meet domestic and foreign market demands; able to utilize maximum applications of fertilizer without lodging and sterility; and adapted for handling by modern methods of production and processing.

The objectives of the breeding program are subject to revision to take into consideration changes in cultural practices, increased prevalence of old diseases or the advent of new diseases and the need for adapted varieties for new uses or to meet changes in the requirements of producers and processors.

To carry out an effective breeding program, it is necessary to conduct research on the mode of inheritance of important characters and to develop effective methods to test breeding material for the various characteristics. Other papers to be presented on this program will give details of specific problems being studied. Much of this work is in cooperation with pathologists, entomologists, physiologists, chemists and soil scientists.

*Research Agronomist, Crops Research Division, ARS, USDA, Beltsville, Maryland.

Cytological Studies of Rice

Birdie Yeh and M. T. Henderson*

The objectives of the research to be reported included cytogenetic relationships among diploid species of Oryza and origin of the cultivated species *O. sativa* and *O. glaberrima*. The materials involved consisted of nine diploid species and hybrids between them. These species were *O. sativa* (several varieties), *O. sativa* var. *fatua, O. sativa* var. *formosana, O. balunga* or *O. perennis* var. *balunga, O. perennis* var. *cubensis, O. perennis* var. *barthii, O. glaberrima, O. breviligulata* and *O. stapfii*. The research was conducted from 1957 to date.

Four types of information pertaining to cytogenetic relationships among the species were obtained: (1) geographical distribution of the species, (2) morphological characteristics of the species, (3) chromosome behavior during meiosis in F_1 of hybrids and (4) hybrid fertility. In the study of chromosome behavior in meiosis, the hybrid material was examined for evidence of irregularities in chromosome pairing during diakinesis and metaphase I and in chromosome disjunction during anaphase I. Hybrid fertility was measured by the percentage of pollen stainable in acetocarmine. Only when the percentage of stainable pollen was consistently lower than that found in partially sterile intervarietal hybrids of *sativa* were the results given special significance.

The nine species were divided into groups of closely related forms. The first of these groups includes *O. sativa, O. sativa* var. *fatua, O. sativa* var. *formosana* and *O. balunga* (*O. perennis* var. *balunga*). All of these forms are indigenous to Southeast Asia. The last three are wild types. *Fatua* and *formosana* are very similar morphologically to *sativa,* while *balunga* differs considerably from *sativa* in several characteristics, particularly prostrate growth habit and distinctly perennial nature. All three of the wild forms show premature shattering of the grain. Chromosome behavior during meiosis in all F_1 hybrids between *sativa* and the three wild forms of this group was normal, with no more irregularities than found in intervarietal hybrids within *sativa*. All of the hybrids between members of this group were highly or completely fertile. Although some showed a degree of partial sterility, none was appreciably more sterile than found in partially sterile intervarietal hybrids in *sativa*. It was con-

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cluded that the four forms included in this group were closely related, contained the same chromosome genome and perhaps could be placed in the same species. However, the authors feel that because of its sharp morphological differentiation from *sativa,* the form *balunga* should be recognized as a separate species.

The second group consists of the two forms of the species *O. perennis,* designated var. *cubensis* and var. *barthii.* These forms resemble *sativa* somewhat in morphology, particularly var. *cubensis,* but differ in several respects. Chromosome behavior during meiosis in hybrids of *sativa* with these two forms of *perennis* was regular, resembling that found in the first group. However, all hybrids of *sativa* with these two forms were completely or almost completely sterile.

From these results it was concluded that because of the virtually complete sterility found in all hybrid combinations, the two forms of *perennis* represent distinct species from *sativa.*

The wild forms which have been designated *O. balunga, O. perennis* var. *cubensis* and *O. perennis* var. *barthii* in this paper require special consideration. The occurrence of the form *balunga* in India was not recognized until 1951. Recently, workers there classified it as a botanical variety of *O. perennis* and designate it *O. perennis* var. *balunga.* In the present study, the so-called *balunga* form appeared to be more closely related to *sativa* than to the *cubensis* and *barthii* forms. Because of differences in geographic distribution, morphology and the indirect evidence that *balunga* is much closer to *sativa* than to the other two forms, the authors feel that the *balunga* form deserves separate species rank and have designated it tentatively as *O. balunga.* Direct evidence concerning the relationship among these three forms will be available shortly.

The third group consists of three related species which are native to tropical West Africa . . . *O. glaberrima* (cultivated), *O. breviligulata* and *O. stapfii.* Because of the extremely close cytogenetic relationship found among these three species, they are treated as a group in this paper and only results from hybrids between *glaberrima* and *sativa* will be presented. Although both of these species are cultivated and in taxonomic treatments of the genus have been differentiated primarily on the basis of the short ligule and glabrousness of *glaberrima,* these two forms actually differ also in other morphological and physiological characteristics. In the investigations conducted by the authors, irregularities in chromosome behavior were found consistently in all hybrid combinations during all stages of meiosis which were studied. These irregularities consisted of an abnormally high frequency of univalents, unequal disjunction and lagging of chromosomes, and absence of cell walls between nuclei in dyads and quartets. In all crosses, most microspores stopped development at the quartet stage. In regard to fertility, none of the *glaberrima-sativa* hybrids showed more than a trace of stainable pollen and all were completely or almost completely sterile.

Based on the several lines of evidence mentioned previously, it was concluded that the African cultivated form *glaberrima* is a distinct species from *sativa,* and the cytogenetic relationship between these two species is more distant than that between *sativa* and the wild species discussed previously.

It is pointed out that the report of irregularities in chromosome behavior during meiosis in *glaberrima-sativa* hybrids in the present studies are not in agreement with earlier publications by the Japanese cytologist Morinaga who reported regular chromosome behavior in this type of hybrid.

Based on the cytogenetic data obtained in the study consisting of chromosome behavior in meiosis and fertility of the hybrids, a proposed designation of genomes was formulated for the nine species. All species which showed no cytogenetic differentiation were assigned the same genome letter designation. Species having regular chromosome behavior, but showing abnormally high sterility in hybrids, were considered to have the same basic genome and were assigned the same letter, but were given different subscript numbers. Species showing significant irregularities in chromosome behavior and abnormally high sterility in hybrids were considered to have different genome constitutions and were assigned different letters. The species *O. sativa, O sativa* var. *fatua, O. sativa* var. *formosana* and *O. balunga* were assigned the same genome designation, A_1. The genome of the *O. perennis* forms was designated as A_2. The three African species, *O. glaberrima, O. breviligulata* and *O. stapfi,* were given the symbol E.

The results of these investigations provide new evidence concerning the origin of the cultivated species *O. sativa* and *O. glaberrima.* The most commonly accepted theory regarding *O. sativa* proposed that it was originated from the similar, highly variable wild form, *O. sativa* var. *fatua.* Recently, Indian workers proposed that *O. sativa* was derived from an Asiatic form of *O. perennis,* which has been designated *O. balunga* in the present paper. The authors are of the opinion that the original wild progenitor of *O. sativa* was the species designated *O. balunga.* It also is felt that the early forms of cultivated rice probably resembled *O. sativa* var. *formosana,* being perennial in habit, but less procumbent and showing less tendency to shatter than *O. balunga.* Such forms probably represent a step in the domestication of *O. balunga* to *O. sativa.* It also is felt that the annual, strongly shattering form *O. sativa* var. *fatua* probably arose from natural hybridization and was not the progenitor of *O. sativa.*

As early as 1914, it was suggested, on the basis of morphology, that *O. glaberrima* was derived from the African wild species *O. breviligulata.* The cytogenetic evidence obtained in the present studies indicates that *O. glaberrima* had a separate origin from *O. sativa* and confirms the theory that *O. glaberrima* was derived from the closely related species *O. breviligulata.*

A practical aspect of the results obtained in these studies pertains to the possible improvement of *O. sativa* through interspecific hybridization. Because of close chromosome homology and high fertility in hybrids, the wild forms *O. sativa* var. *fatua, O. sativa* var. *formosana* and *O. balunga* could be utilized if found to possess superior germ plasm. Because of the almost complete sterility in hybrids between *O. sativa* and the other species studied, however, it is doubtful that these species could be utilized successfully in the breeding of *O. sativa* unless special means can be found to overcome the sterility barrier.

Standardization of Gene Symbols for Rice

Nelson E. Jodon*

Progress in rice genetics has been retarded by isolation of workers, language barriers and emphasis on practical results in the form of improved varieties. The mapping of chromosomes in rice is much less advanced than in barley, for example. No standards for the symbolization of genes have gained world-wide acceptance, but the FAO International Rice Commission is now implementing rules of nomenclature promulgated by the Xth International Genetics Congress by recommending symbols for the better known genes in rice. A mimeographed report on symbolization and linkage is available and an expanded review-report summarizing gene segregation and linkage data and listing recommended symbols is in preparation.

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Hybrid Sterility in an Intervarietal Cross of Rice

H. R. Caffey*

Two expressions of fertility, percent seed set and percent stainable pollen were used to study the behavior of fertility in the cross CI 6008 x Dischler's Selection. Both parents had a mean seed set and stainable pollen percentage greater than 89 percent in 1956 and 1957. Most of the plants of both parent varieties showed seed set and stainable pollen to be above 90 percent both years.

The seed set of the one F_1 plant from this cross was 41.5 percent. The F_2 population produced a mean seed set of 48.3 percent. The distribution of F_2 plants showed a continuous range from 0 to 100 percent. The plants could not be classified into distinct and separate groups according to seed set that would permit identification of ratios. Fertility did not behave as either a typical qualitative or quantitative trait.

Five of 91 F_3 lines evaluated appeared to be homozygous for normal fertility. No partially sterile F_3 lines bred true. Completely fertile segregates occurred in 90 of the 91 F_3 lines studied. This indicated that no plant selection in an intervarietal cross should be discarded because of its low fertility. The F_3 results of seed setting also failed to reveal any evidence that sterility was caused by a genic mechanism. The behavior of sterility in this intervarietal cross could be accounted for more readily by structural differentiation of the parental chromosomes.

The pollen stainability studies revealed information almost identical to that determined by seed set studies. The 866 F_2 plants examined showed a continuous range from 1 to 98 percent stainable pollen. The F_3 means showed a continuous distribution from 21 to 91 percent stainable pollen. Eleven of the 91 F_3 lines appeared to breed true for normal fertility. None of the lines was found to breed true for partial sterility and some completely fertile plants occurred in 90 F_3 lines. The F_2 and F_3 pollen stainability data agreed with those of the seed set. There was no evidence of a genic cause of sterility. The pollen stainability study also backed an earlier finding. Completely fertile F_3 plants could be obtained in this intervarietal hybrid from F_2 plants with low stainable pollen.

This study revealed only negative evidence for the fertility being caused by genes, but the results could be accounted for easily by structural differences in the chromosomes.

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Mode of Inheritance of Hoja Blanca Resistance in Rice

H. M. Beachell and Peter R. Jennings*

Shortly after the hoja blanca virus was recognized as an insect-transmitted disease, resistant and susceptible strains were found within several United States rice varieties. Varieties behaving in this manner were Early Prolific, Blue Rose and Colusa. Resistant and susceptible pure-line hybrid selections were recovered from crosses between resistant and susceptible varieties. This would indicate that resistance might be controlled by a small number of genes.

The reaction of single cross F_1 plants, backcross F_1 plants and F_3 and F_4 line selections tends to indicate that resistance is dominant and controlled by one major gene pair. However, modifying genes may be present that have some influence on the degree of resistance of a given variety.

The data reported were obtained on hybrid material being tested in a breeding program designed for the rapid development of adapted hoja blanca-resistant commercial varieties. For this reason, the inheritance data presented are limited in scope. They do give some indication as to the mode of inheritance of resistance to the disease.

F_1 Plant Data

Resistance appeared to be a dominant characteristic, based on the reaction of 182 F_1 plants from 102 different crosses between resistant and susceptible varieties. Some 162 plants were either resistant or moderately resistant (89 percent) and 20 plants (11 percent) were susceptible. The susceptible F_1 plants can not be explained fully. They occurred in 17 different crosses involving 9 different resistant parental varieties.

Some of the F_1 plants from resistant x susceptible crosses that were classified as susceptible may have been the progeny of susceptible segregates occurring in the resistant parental varieties. A more likely possibility is that the F_1 plants classified as susceptible actually were resistant plants that were heavily infected with the virus. Later studies have shown that resistant plants will develop typical susceptible leaf symptoms when subjected to a heavy infection. Unfortunately, the F_1 plants classified as sus-

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ceptible were not carried into the F_2 plant generation to determine whether resistant segregates were present.

F_1 plants from four crosses between resistant x resistant varieties showed 10 resistant and 1 susceptible plants.

Backcross Data

F_1 backcross plant data from four combinations of (RxS) x R showed 32 resistant, 5 moderately resistant and 8 susceptible F_1 plants. Theoretically, all plants should have been resistant, assuming complete dominance.

Twenty-five backcross combinations of (RxS) x S showed 47 resistant and 58 susceptible F_1 plants, a close fit to a theoretical 1:1 ratio.

F_3 and F_4 Line Data

Some 506 F_3 panicle selections representing 102 different F_2 plant families from four different crosses were tested in Colombia in the fall and winter of 1959-60. The F_2 panicle selections had been tested for hoja blanca reaction in the F_3 plant generation under conditions of moderate infection and only those lines appearing to have resistance were saved. An extremely heavy vector population occurred on the F_4 plants and susceptible leaf symptoms were observed on resistant varieties. Of the 102 families tested, only 14 were classed as susceptible. The remaining 88 were classed as resistant or segregating resistant and susceptible.

Based on the reaction of resistant and susceptible parental rows under the conditions of extremely heavy infection, those rows showing more than 60 percent disease-free plants were classed as resistant. Rows showing above 20, but below 61 percent disease-free plants, were classed as segregating and rows showing 20 percent disease-free plants or below were classed as susceptible.

The 66 families classed as segregating included a total of 323 F_4 lines. Of this number, 237 were classed as either resistant or segregating and 86 as susceptible. This gives a good fit for a 3:1 ratio (243 to 81).

Progress in Breeding for Resistance to Hoja Blanca

Charles N. Bollich*

At the end of 1957, the first year in which hoja blanca research was conducted in Cuba and Venezuela by the U. S. Department of Agriculture and cooperating agencies, the following significant facts were indicated:

1. All leading United States varieties are susceptible to hoja blanca.

2. Several minor United States varieties with short and medium grain lengths (Colusa, Lacrosse, Arkrose, Asahi and Missouri R-500) are resistant, but no resistant long-grain varieties were found.

3. Pure-line selections derived from certain crosses of resistant x susceptible parents were variable in reaction, some being resistant and others susceptible, an indication that resistance was controlled genetically.

4. A few resistant long-grain selections were found but none was commercially suitable. Their existence indicated the probability that resistant varieties of all commercially important grain types could be developed.

This information formed the basis for breeding programs initiated at United States rice experiment stations to meet this potential threat. Generally, these breeding programs have consisted of two phases:

1. A continuation of testing for hoja blanca reaction of old varieties, selections and hybrid populations from the breeding nurseries of United States rice experiment stations and the U. S. Department of Agriculture world rice collection.

2. Hybridization programs involving crossing the newly identified sources of resistance with leading commercial varieties.

Under the first phase of these programs, several thousand varieties and selections have been tested since 1957 at foreign locations where the disease was present. These tests have verified the resistance of Lacrosse, Colusa and Arkrose and resulted in the discovery of additional resistant sources. As a result of these programs, a new medium-grain variety, Gulfrose, was released recently in Texas. With this new variety and the other reasonably satisfactory resistant short and medium-grain varieties that have been found, the United States rice industry appears to be in a relatively secure position in respect to hoja blanca in so far as these grain types are concerned.

Substantial progress has been made in the hybridization phase of the program. The main sources of resistance utilized have been Lacrosse, Gulfrose, P. I. 215936 and Colusa. Principal breeding methods used have been backcross and pedigree, and combinations of these. By 1961, a rather large number of true-breeding resistant long-grain types will be available for field testing at the experiment stations in the Southern rice area. Some of these should be satisfactory for commercial production.

Principal obstacles to the program have been (1) the necessity of relying on natural infection for classifying the breeding material for hoja blanca reaction, (2) a lack of knowledge of the mode of inheritance of resistance and (3) the fact that the selections had to be tested for disease reaction at foreign locations away from the centers of breeding in the United States. In spite of the obstacles, much material has been and continues to be screened.

Because of the seriousness of the hoja blanca threat, emphasis is being placed on obtaining resistant varieties equal in all other respects to the present commercial ones. But the ultimate goal is to obtain varieties of all grain types that are superior to the present commercial ones and that combine resistance to all important diseases with improved plant type, lodging resistance, higher yielding ability and superior milling, cooking and processing characteristics to suit all segments of the rice trade.

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Breeding for Increased Protein Content in Rice

T. H. Johnston*

Crosses were made in the field in 1951 and the F_1 plants were grown in the greenhouse during the winter and transplanted to the field in 1952. Seed from the F_1 plants were seeded in the field and the resulting plants were spaced by transplanting.

Protein determinations were made of grain from individual F_1 and F_2 plants. Seed were saved from both F_1 and F_2 plants. Spaced F_2 plants and F_3 lines were grown in the field in 1953 for further protein determinations. F_2 and F_3 populations of six separate crosses were studied in 1952 and 1953 and in nearly all cases the mean protein percentages of the hybrids were appreciably higher than those of either parent in the same test.

Based on the protein percentages of the grain of F_3 lines grown in 1953, a number of lines were designated as "low-protein" (5.50% or below) and "high-protein" (7.75% or above) lines. The F_4 progenies of these were grown in 1954. Many of the "low-protein" lines happened to be seeded on highly alkaline soil spots and plants for the most part made very poor growth. Under these conditions, two of the "low-protein" lines produced two of the three highest protein percentages. Five of these lines which averaged only 4.99% in 1953 had an average of 8.99% protein in 1954. Most of the "high-protein" lines continued to produce relatively high protein percentages in 1954, with the range for 42 lines and parents extending from 6.36 to 9.99%.

About 270 lines and parent check rows were grown in 1956. Protein percentages were variable, with two rows of Zenith showing 7.26 and 9.23% compared with 8.56 and 8.09% for two adjacent rows of Adt. 3. The range for hybrid lines was from a low of 7.44 to 10.20%.

Further selections from the hybrid lines were grown again in 1957 and in 1958. Protein percentages on the 1958 crop ranged from 5.89 to 10.12%.

Although the protein percentages as determined in this study (total N x 5.95) were influenced to a considerable extent by environmental conditions under which the plants were grown, the results obtained appear to justify the conclusion that lines have been isolated which have higher inherent protein content than the parent varieties.

Experiments were started in Arkansas in 1950 to increase the protein content in rice grain through a breeding program. Seed of three varieties reported to have high levels of protein content were obtained from India for use as "high-protein" parents. The varieties and their reported protein contents were:

VARIETY	PROTEIN % (INDIA)	PROTEIN %—GREENHOUSE (ARKANSAS SEED INCREASE)
Adt. 3	10.5	11.5
Co. 9	9.6	8.3
Co. 10	7.6	8.3

Commercial varieties used as "low-protein" parents showed the following protein content (total N x 5.95):

VARIETY	PROTEIN %—FIELD—ARKANSAS
Zenith	7.2
Arkrose	6.8
Rexark	6.7
Caloro	6.3
Early Prolific	6.0

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Development of an Adapted Long-grain Rice Variety for California

Joseph R. Thysell*

The main objective in the rice improvement program for California is the development of stiff-straw, cold-hardy, short, medium and long-grain varieties that are disease resistant; that have good milling and cooking quality and have the desired kernel characteristics.

Interest in the development of a long-grain rice variety for California is not new. Long-grain varieties from the rice-growing areas of the Southern States and the other parts of the world have been tested at the California Rice Experiment Station since its establishment in 1912. To partially offset the loss of many foreign markets for California short-grain rice, renewed interest has been expressed in the development of an adapted long-grain rice variety to meet the specific demands of food-processors and rice-millers on the West Coast. During 1950-58, southern long-grain varieties were crossed with the three varieties grown commercially in California and with other long-grain selections that had good seed-set. In all, more than 100 crosses were made. Many of the lines from these crosses have been eliminated, mainly on the basis of plant type and general lack of adaptation.

Major problems in the development of a superior long-grain variety are early maturity and a high percentage of spikelet fertility. Many of the early attempts were made by crossing the better long-grain types from the Southern States onto locally adapted short-grain varieties.

Most of the long-grain varieties matured later than the locally grown varieties. With the use of controlled day-length chambers, it is now possible to make crosses between varieties differing widely in response to day-length.

A rice nursery was grown in 1957 in Kern county in the southern part of San Joaquin Valley of California to evaluate the general adaptation of new long-grain varieties for California. Most of the 54 long and medium-grain varieties tested did not perform as well as the check

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varieties, Caloro and Calrose. No yield determinations were taken, but the varieties were rated on their relative performance based on percentage sterility, vigor, stand and speed of emergence through the water. The long-grain selection, California 405AI-3-6-3-3, demonstrated its ability to emerge rapidly through the water, grew vigorously and it had a heading date comparable with the early maturing variety, Colusa (C. I. 1600). In preliminary yield-plots (water-seeded) in 1958 it averaged approximately 5,900 pounds per acre. It was included in water-seeded yield nurseries in 1959 at Biggs and at Bakersfield in Kern county. Its performance is summarized in the following:

VARIETY	NUMBER OF DAYS FROM SEEDING			YIELD, LB/A	GRAIN TYPE
	EMERGENCE	HEADING	MATURITY		
Calif. 405A	17	89	118	5000	Long-grain
Calrose	16	101	154	4850	Medium-grain
Caloro	17	105	154	4750	Short-grain
Colusa	16	85	126	4590	Short-grain

A small increase plot of 405A1-3-6-3-3 was grown in 1959 at the Rice Experiment Station at Biggs. A wide variation was observed in the percentage of sterility between panicles from individual plants. Panicles were collected from 1,000 individual plants and these were sown in a head-row nursery in 1960.

The iodine-blue value and gelatinization temperature were determined for 75 long-grain selections from the 1959 breeding nursery at the Cooperative Rice Quality Laboratory, Beaumont, Texas. Twenty-six of these lines showed promise from a quality standpoint. These lines were sown in single, water-seeded plots in 1960.

None of the long-grain varieties now under test at the experiment station has shown resistance to the disease hoja blanca. To incorporate resistance into existing long-grain selections, crosses onto the two resistant varieties, Colusa and Lacrosse, were made in 1958 and 1959. Lines from these crosses are being grown in disease nurseries in South and Central America and in Louisiana.

In screening rice varieties from the world collection for cold-water tolerance, the only long-grain variety that thus far has shown any degree of tolerance is Calif. 405A1-3-6-3-3. Other long-grain varieties from the world collection will be tested for cold-tolerance during 1960 and 1961.

Effect of Temperature During Ripening on Quality Characteristics of Rice

John V. Halick*

The influence of temperature during the ripening period on quality characteristics has been studied for the past 3 years. Temperature differences were obtained by conducting the experiment in two phases. First, a uniform group of varieties were grown at Beaumont, Texas, and at Stuttgart, Arkansas, where there usually is a 7 to 12° F. difference in the temperature during the ripening period. Second, a comparable temperature differential was obtained in a date-of-seeding experiment conducted at Beaumont.

Temperatures during the ripening period as influenced by the date of seeding had a marked effect on several quality characteristics of rice. As a general rule, a variety ripened under lower temperatures (81 to 84° F.) produces higher total and head rice milling yields than it does when ripened earlier under higher temperatures (90 to 94° F.). There was a marked lowering in iodine values with the cooler temperatures, indicating that the deposition of amylose was enhanced at the expense of the branched starch component. This observation was borne out by analytical determinations of the amylose content. The cooler temperatures in almost all cases resulted in a marked lowering in the gelatinization temperature as measured by the Brabender Amylograph. Concurrent with the lowered gelatinization temperature, there were marked increases in water uptake capacity and an increased susceptibility to digestion by dilute alkali. This was expected since these characteristics are so closely related. The later date of seeding, with its cooler temperatures, also resulted in a marked decrease in the Amylographic viscosity of the hot paste and an increase in gel formation on cooling to 50° C.

Comparison of rice varieties grown at Beaumont, Texas, and Stuttgart, Arkansas, showed quality differences parelleling trose found in the date-of-seeding study. These differences were thought to be due to lower temperatures occurring at Stuttgart during the ripening season.

The effect of temperatures during the ripening period on quality characteristics is extremely important since one of the objectives of the breeding programs is to develop earlier-maturing varieties that would ripen during the hot weather peak of the summer. A more thorough understanding of the basic relationships between these and other environmental conditions are necessary to produce rice with consistently satisfactory processing characteristics.

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Influence of Temperature on Heading Dates and Grain Characteristics of Rice[1]

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Environmental and genetic factors are the main variables controlling the biochemical nature of rice starch. An

[1] Preliminary report of research conducted to fulfill partially the requirements for the degree of doctor of philosophy, Purdue University. Contribution from the Department of Agronomy, Purdue University; Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture; the Texas Agricultural Experiment Station, the American Rice Growers Association; and the Texas Rice Improvement Association.

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understanding of the influence of both of these variables is essential in the development of new endosperm types in rice. A preliminary study of genetic variability as it influences amylose content and birefringence end-point temperature (BEPT) will be completed this summer. This paper is concerned with the influence of day-night temperatures on endosperm characteristics of rice.

Four rice varieties, Century Patna 231, Bluebonnet 50, Toro and a medium-grained waxy (glutinous) type, were grown in the control climate facilities at Purdue University. The 4 day-night temperature combinations used were 90° F. day-80° night, 90° day-70° night, 80° day-70° night and 80° day-60° night. All chambers were held at a constant humidity, a constant light intensity and a 12-hour day length.

The characteristics studied were BEPT, percent amylose, kernel width, kernel length, chalkiness and heading dates. Iodine values are yet to be determined. Milling data were taken, but the samples were too small for reliable results.

A very pronounced and uniform influence of temperature on BEPT was found. Day and night temperature had equal influence. As temperature was lowered, there was a corresponding decrease in BEPT. All varieties seemed to be influenced equally by temperature.

The amylose-amylopectin ratio of rice starch also was influenced by temperature. As temperatures were decreased, the percent amylose was increased. The influence is not linear as was found in the BEPT data.

These data explain clearly the date-of-seeding results discussed in an earlier paper on this program. Apparently temperature plays a major role in differential cooking behavior as has been noted for early and late-maturing rice. The breeder must take into account the influence of temperature when he selects for cooking and processing characteristics.

Kernel size also was influenced by temperature. A negative correlation of temperature and kernel width was the major factor contributing to the reduction of the kernel length-width ratio as temperature decreased. Kernel length seemed to be more variable than width.

With the varieties used in this experiment, it was expected that heading would be initiated later as temperatures were lowered. In Century Patna 231, an early-maturing type, cooler temperatures (except the 80° day-60° night treatment) induced earlier heading. Lower temperatures delayed heading of Bluebonnet 50, a mid-season type. The differential responses of Century Patna 231 and Bluebonnet 50 to temperature resulted in Bluebonnet 50 heading earlier than Century Patna 231 by 5 days at 90° day-80° night.

In general, as temperatures were reduced, dates of heading of both Toro and the waxy type were delayed. However, night temperature seemed to have a greater influence on the heading of Toro while the other varieties were affected equally by day and night temperatures.

The higher temperatures increased chalkiness in all varieties. Bluebonnet 50 was affected most. At 90° day-80° night, 15 percent of the Bluebonnet 50 kernels showed definite chalkiness.

These data leave little doubt that temperature plays a major role in the agronomic and biochemical characteristics of rice. However, temperature is but one of many environmental variables influencing plant response. By understanding these variables, the breeder will be able to do a much more efficient job of producing desirable varieties.

Processing, Composition and Nutrition Section

E. A. Fieger, Moderator

Basic Research on Rice Composition

Virginia R. Williams*

Studies over the past 5 years have been directed toward rice starch and protein. Results on varietal differences in starch composition as revealed by amylose-amylopectin ratios have been reported at previous meetings.

Processing characteristics not explainable on the basis of these ratios have led to the determination of amylose molecular weights for four varieties by the periodate oxidation method. Present results corrected for traces of amylopectin gave the values: Century Patna, 29,000; Rexoro, 41,000; Zenith, 41,000; and Caloro, 48,000. Certain analytical problems in connection with the assay necessitate qualifying these figures as tentative values. These analytical problems are being studied.

The characterization of rice proteins by starch electrophoresis has been initiated. Preliminary studies are being conducted on the rice protein-detergent complex (Santomerse).

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Effect of Gas Plasma Irradiation on the Hydration of Rice[1]

H. J. Deobald*

Work at the Southern Utilization Research and Development Division is being continued along the same lines as reported 2 years ago. We are continuing work on the effect of age on rice constituents. Three hundred samples of long and medium-grain rice have been analyzed in a cooperative study to compare domestic rice with those in foreign commerce. Our major efforts have continued to emphasize fundamental chemical and physical properties of rice.

[1] Report of progress on rice gas plasma irradiation studies is based on the cooperative investigations of A. S. Roseman and J. T. Hogan of the Southern Utilization Research and Development Division, New Orleans, Louisiana, and of R. B. Stone and J. C. Webb of the Agricultural Engineering Research Division, Knoxville, Tennessee—ARS, USDA.

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During the past year, we have been able to demonstrate that gas plasma irradiation has a marked effect on the hydration characteristics of rice. The general progress reported here on the effects of irradiation was done with the cooperation of Agricultural Engineering Research Division, Agricultural Research Service, which first demonstrated the marked effect of this phenomenon on cottonseed, fiber, soybeans and corn. The apparatus used for glow discharge treatment was a pyrex tube about 2 inches in diameter and 2 feet long. Two black iron couplings were held in position on either end of the tube by means of rubber stoppers. After evacuating, currents in the range of 50 to 145 ma. were generated by means of suitable transformers. Two varieties of milled, whole grain rice were subjected to a gas plasma irradiation at a pressure that was low enough to permit the generation of a glow discharge across electrodes. Three variables were studied in the hope of attaining the maximum effect of the treatment. These were: time, pressure and electrical intensity.

In brief, the results were: 1. with the time and pressure constant at 5 minutes and 2 mm. Hg, respectively, maximum changes in hydration characteristics occurred at about 175 ma. for Zenith and 150 ma. for Bluebonnet 50 rice; 2. within the pressure range of 2 to 8 mm. Hg with a current of 25 to 72 mm. for 5 minutes, pressure during treatment had no great effect on changing the water absorptive capacity; and 3. at 50 ma. and 2 mm. Hg pressure, any increase in treatment time over 45 minutes for Bluebonnet and 70 minutes for Zenith was inefficient in increasing the amount of water absorption.

Information obtained during the past year is being subjected to further evaluation and a manuscript reporting details of the findings will be submitted for publication in the near future.

Differences in Rice Varieties– A Processing Problem

D. R. Sidoti and T. J. Canavan*

In the processing of any food product, raw material is a key factor in terms of finished product quality and cost. When the processor has a choice of raw materials at his disposal, differences in quality can be a significant problem. In 3 years experience with our present process, we can say that varieties do differ signficantly in terms of their processing ability and do represent a significant problem in terms of quality and economy. The problem of varietal difference affects the entire rice industry, for when rice is prepared in the home it is subjected to treatment similar to processing conditions. If a rice variety shows low tolerance to hot water and steam, there is reason to believe that what cooks into a poor plant product will be equally as poor in the home.

In line with our raw material supply, it has been our practice to evaluate new rice varieties and experimental crosses. During the course of our evaluations, we have come on two varieties (Century Patna 231 and Toro) which typify processing problems caused by varietal differences. Since the reactions of these two varieties to processing are similar, I will point out our specific processing problems with Century Patna. Our major problem with Century Patna is its low tolerance to hot water and steam. As hot water is absorbed into the grain, the structure of the grain appears to granulize and a degree of disintegration takes place. Those grains which do not disintegrate give the appearance of granules of starch held together by a translucent gelatinous mass. Since the product must be dried, the delicate condition of the grain presents a problem. We have found that rice in this condition is virtually impossible to separate into individual grains after drying. These two factors make the use of Century Patna and Toro unsuitable for processing from a quality and economic standpoint.

In our research efforts to solve the problem of varietal differences, we have taken two approaches. The first is to deal with the immediate problems caused by varietal differences. This is being done through the development of quality control tests to detect the presence of rice varieties which we have found to be unprocessable.

Our second approach is to support basic research aimed at determining the causes of varietal differences. This is being done through General Foods grants-in-aid. A program at Louisiana State University on the basic chemistry of rice is contributed to through a grant-in-aid. A grant-in-aid also is made available at the Texas Agricultural Experiment Station for the evaluation and development of new rice varieties.

Our future plans are to continue working on this problem in four ways: 1. sponsorship of basic rice research; 2. by evaluating new rice varieties for processability; 3. by refining existent tests and applying new promising methods for obtaining estimates of processability of raw rice; and 4. by continuation of contacts with others interested in the rice industry.

The problems presented by varietal differences are not the same for all aspects of the rice industry nor are they easily solved. However, we feel that with the cooperation of all groups, together with continued research, solutions to all of the phases of this problem will be obtained.

***Project Leader and Skilled Technician, respectively, Jell-O Division Laboratories, General Foods Corporation, Tarrytown, New York.**

Effect of Granule Hardness, Molecular Weight and Degree of Branching on the Gelatinization Temperature of Rice Endosperm[1]

J. W. Stansel, Roy L. Whistler and H. H. Kramer*

[1] Preliminary report of research conducted to partially fill the requirements for the degree of doctor of philosophy, Purdue University. Contribution from the Department of Agronomy and Biochemistry, Purdue University; the Texas Agricultural Experiment Station; the American Rice Growers Association; and the Texas Rice Improvement Association.

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Birefringence end-point temperature (BEPT), or as it is more commonly known, gelatinization temperature, is a very important characteristic of starch. To understand fully the variability of BEPT found in rice starch, one should know what biochemical factors determine BEPT.

Tools and techniques were available in the Department of Biochemistry, Purdue University, to study starch granule density, relative molecular weights and degree of branching of the amylopectin fractions. These variables were studied in eight rice samples in an effort to correlate them to BEPT. Four of the samples were rices possessing differing amounts of amylose and the remaining four were waxy types which contain little or no amylose. The samples had a range of BEPT's from 60 to 76° C.

Amylopectin from the normal starches was isolated from the aymlose and the intermediate fractions by a pentasol fractionation method. Degree of branching and limiting viscosity determinations were made on the fractionated amylopectin and the whole waxy starch. Mercury diffusion determinations were made on normal unfractionated starch and whole waxy starch.

Degree of branching determinations were made by the periodate oxidation method as described by Anderson, Greenwood and Hirst. No correlation was found between the degree of branching and BEPT. Although the degrees of branching within the normal and the waxy starches were similar, the normal and waxy rices were different from each other in their branching properties. The amylopectin of the waxy starches contained fewer side branches than that of the normal starches.

The limiting viscosities of the starch samples were determined by an Ostwald viscometer using 1 N KOH as the solvent. Limiting viscosity is a relative measure of molecular weight. In general, the higher the molecular weight of the starch, the lower the BEPT within the normal amylopectin and the waxy types, with the exception of waxy Zenith. Again, a marked contrast was found between the waxy and normal types. The waxy types had molecular weights higher than those of the normal amylopectin.

A mercury diffusion technique, as outlined by Whistler *et al.*, was used to determine the internal density of the starch granule. Such a technique gives a relative indication of how close the internal molecules are arranged. Isolated starch samples were placed in a 1% $HgCl_2$ solution with constant stirring. At 3, 7 and 11-hour intervals, samples were collected and dried to stop the $HgCl_2$ diffusion. The starch granules were then embedded and sliced to 1/20 micron in thickness. These sections were examined under the electron microscope at magnifications of 4,000 to 5,000 X. Negatives were placed on a light table equipped with a venier scale and the distance which the $HgCl_2$ diffused into the starch granule was measured. Definite cavities were found in approximately 10 percent of the granules observed.

Within either the normal or waxy class, a direct correlation was found between internal granule density as measured by $HgCl_2$ diffusion and BEPT. As internal granule density increased, BEPT also increased. The normal samples had a higher internal density than the waxy types.

These studies indicate that the amylopectin of the waxy rices are different from that of normal rices in all variables measured. The amylopectin of the waxy samples was less branched, higher in molecular weight and the internal granule density was less than the amylopectin of normal starches. Within the samples studied, with one exception, both molecular weight and granule density modified BEPT, but they are not correlated directly to BEPT because of the differences found between the normal and waxy types. Possibly BEPT is controlled by the number and strength of cross hydrogen bonding between the molecules. At a certain temperature, specific for a starch, the molecules have a greater affinity for H_2O than for each other. If this is the case, one can see readily how molecular weight and internal granule density could modify the number and strength of hydrogen bonding, thus modifying BEPT.

Studies in the Cooking Behavior of Several Varieties of Rice

M. Isabel Irwin*

Several studies on the cooking quality of rice have been carried out during the past 3 years in the Home Economics Department at the University of Arkansas. Initial studies dealt mainly with developing a satisfactory technique for conducting routine cooking tests.

Various methods of cooking were tested. These included cooking in a closed and in an open saucepan on top of the stove, cooking in the oven in closed and open dishes, starting the cooking with boiling water and with cold water and subjecting the rice to an initial treatment with dry heat before adding the water. The amount of water and salt to use with a given amount of rice also was tested. Eventually a satisfactory method of cooking was established. This method actually is a modification of one which had been used earlier for cooking brown rice and is:

KIND	AMOUNT	DISTILLED WATER	SALT
Long grain	30 gm.	65 ml.	¼ tsp.
Medium grain	30 gm.	60 ml.	¼ tsp.
Short grain	30 gm.	55 ml.	¼ tsp.

Place rice, salt and distilled water in a 10 oz. pyrex casserole. Cover snugly with aluminum foil. Place in a preheated oven at 375° F. for 30 minutes.

A score card for judging the cooked rice had to be developed. Personnel in the home economics research area were used as judges. Since only a few personnel were available and these were somewhat transient, a simple scorecard was needed. A suitable scorecard was developed, as shown.

Using this method and score card, the cooking quality of three samples of rice was tested in May 1958. This was done at the request of the Rice Branch of the Arkansas Agricultural Experiment Station. The samples tested were Zenith, Gold Zenith (Golden Rose) and Arkrose selec-

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tion C. I. 9198. The taste panel at this time found that Zenith gave a cooked product slightly superior to Gold Zenith. The Arkrose selection was rated as much inferior to the others because of its unpleasant aroma and taste.

The samples had been stored in a refrigerator before and during the tests. Because of a shortage of refrigerator space, the sack of Gold Zenith rice was removed to a dry storeroom at the end of the test. Three months later, the study was repeated with samples from the same three lots of rice. Again the Arkrose selection was judged inferior. The previous ratings of Zenith and Gold Zenith, however, were reversed. Gold Zenith was invariably rated as superior because it was dryer and showed less clumping. The method of storage was suspected of causing this change in rating.

To test this possibility, additional samples of rice were obtained from the Rice Branch Station. These were Zenith, Gold Zenith and Nato. Each sample was subdivided into four parts. One part was stored in a cloth sack in a dry storeroom, another was stored in a screw-top jar in the same storeroom. The other two subsamples were stored in tightly-closed containers in the refrigerator and freezer, respectively. Cooking tests were run on the subsamples of each variety of rice during the next 10 months. Comparisons were made among the varieties and among the methods of storage.

No clear cut differences were found among the varieties. Nato was scored slightly higher than the other two in most cases, but not consistently or sufficiently higher to warrant calling it superior.

Within each variety there were differences due to storage. The rice stored in sacks or jars in the storeroom consistently scored higher than the rice stored in the freezer or in the refrigerator. The former, when cooked, was less moist and less clumped than the latter.

Periodic moisture determinations showed that the rice in the storeroom picked up less moisture than that stored in the refrigerator or freezer. It was decided that the difference in determined moisture probably was due to moisture condensed on the rice. This would then account for the lack of agreement in the earlier tests.

Additional cooking tests were conducted on samples of experimental varieties from Stuttgart. These varieties along with appropriate checks, were:

EIGHT VARIETIES OF RICE TESTED FOR COOKING QUALITY, FEBRUARY 1958

List no.	Variety	C.I. no.	Selection no.	1958 plot nos.
	LONG-GRAIN			
1	Bluebonnet 50 (check)	8990	———	7-2 (133C)
2	Rexoro-7689x(TPxR-SBR)	9186	Stg 521302	13-11(169B)
3	Rexoro-7689x(TPxR-SBR)	9187	Stg 521305	12-7 (168B)
4	Century Patna 231 (check)	8993	———	13-9 (172B)
	MEDIUM-GRAIN			
5	Nato (check)	8998	———	13-5 (159B)
6	Lacrosse X Arkrose	9407	Stg 555971	12-6 (160B)
	SHORT-GRAIN			
7	Caloro (check)	1561-1	———	6-7 (121C)
8	CI8994 X Caloro	9373	Stg 557605	12-11(154B)

In the long-grain group, both C. I. 9186 and C. I. 9187 were judged superior to Century Patna 231. Most of the judges preferred Bluebonnet to the other long-grain varieties. One judge, however, indicated a marked preference for C. I. 9186.

Of the medium-grain rices, Nato was considered superior to C. I. 9407. The latter had a slight unpleasant aroma. In the short-grain group, C. I. 9373 was judged unanimously superior to the Caloro check. In an overall choice, Bluebonnet was judged by three of the panel the most preferred. One judge preferred C. I. 9186. She is Chinese and probably has developed preferences somewhat different from those of the other judges.

In another series of tests, samples of Bluebonnet rice grown under varying experimental conditions in Jasper county, Texas, were tested for cooking quality. Although information was not available as to the conditions under which these samples were grown, it was noted that, regardless of the combination of the samples or the order in which they were presented, the judges invariably designated sample 3 inferior to the others. This indicated that the cooking method, though based on subjective testing, gave reproducible results.

A graduate assistant, Miss Louise Lovell, is working on the use of rice flour in bread. She already has developed a palatable loaf using long-grain rice flour in combination with all-purpose wheat flour and is continuing her studies.

SCORE CARD FOR COOKED RICE

Name.. Test.........................

Date.. Code.........................

		1	2	3	4
Color					
Snowy white	(3)				
Slightly off color	(2)				
Off color (brown, yellow, green, gray)	(1)				
Separation of kernels					
Separated	(3)				
Slightly clumped	(2)				
Clumped	(1)				
Shape of kernels					
Whole, intact	(3)				
Slightly ragged but not broken	(2)				
Split, ragged, broken	(1)				
Texture					
Firmness					
Firm but tender throughout	(3)				
Soft	(2)				
Hard centers	(1)				
Soggy	(1)				
Consistency					
Mealy	(3)				
Slightly chewy	(2)				
Chewy	(1)				
Moisture					
Dry and light	(3)				
Moist but all moisture absorbed	(2)				
Excessive moisture	(1)				
Very dry (dried out and crusty)	(1)				
Flavor					
Superior—excellent	(3)				
Acceptable but not optimum	(2)				
Undesirable—off flavor, raw taste scorched	(1)				
Overall preference..					

Some Factors Influencing Rice Hot-paste Viscosity

Ernest B. Kester*

A study of the hot-paste viscosity characteristics of rice flours as influenced by different factors is important because the information gained contributes to fundamental knowledge of this cereal and may be related to the water-absorbing and cooking characteristics of whole-grain rice.

Viscosity data of this study were obtained on 10 percent rice flour pastes with the Brabender Amylograph[1] which measures resistance to shear in a rice flour slurry during programmed heating and cooling. Only peak viscosities recorded on the Amylogram during the heating period above the gelatinization range are considered in this report.

Variety

The peak viscosity values for fully mature samples of 13 domestic rice varieties plotted against their amylose content showed a general trend toward linearity, with the high amylose varieties usually having the lower peak viscosities. Exceptions, however, were noted, such as the viscosity of Caloro, a low amylose rice, falling between high-amylase Rexoro and Bluebonnet. Departure from the general trend may be accountable to other factors such as amylose activity, differences in molecular weight of corresponding starch fractions and protein constitutents. Protein content by itself showed no apparent relationship to viscosity among the varieties tested.

Fertilizer

Samples of rice taken from Biggs Station (Calif.) plots or on nearby farms where fertilizer had been applied to the soil in definite amounts, showed consistently lower viscosities for those which had had nitrogen or nitrogen plus phosphorus, than those grown without added fertilizer. These samples also had an appreciably higher nitrogen content than the control samples. Phosphorus applied by itself also produced lowering of peak viscosity, but the samples were not consistently higher in this element as a result of the treatment.

Maturity

Caloro and Calrose samples from Biggs Station test plots, each harvested at successive stages of maturity starting at moisture contents above 50 percent, showed an initial decline of peak viscosity during the harvest period, followed by a rise during the last stages of field drying.

Storage

Milled rice maintained at 34° F. showed little or no change in peak viscosity, but, at ambient temperatures, peak viscosity increased with time, and at 100° the rate of rise was greater. Similar observations were made on wheat flour by Selman and Sumner (Cereal Chem. 24: 291-299 (1947)). Some evidence was found that after a considerable time at 100°, the peak viscosity may start to fall, probably due to decomposition effects. Development of fat acidity was considered a possible influence in the increase of hot-paste viscosity, but from limited tests with added oleic acid, this factor would not seem to account for the magnitude of the observed rise in peak viscosity.

Discussion

Within a variety of rice, its culture, stage of maturity, amylose content and storage history contribute definitely to its hot-paste viscosity behavior. Fundamental reasons for viscosity variations probably lie in changes in molecular structure of the amylose, amylopectin or protein constituents in various environments. Enzymatic action also may be influential. Minor constituents such as fiber, ash and hemicelluloses were not studied, but probably do not influence viscosity to a great extent.

More basic information on viscosity behavior could be obtained by testing isolated starch fractions and relating the data to molecular structure as well as to the source and history of the rice samples of origin.

Acknowledgment

The assistance of Dwight Finfrock and associates of the California Rice Experiment Station in furnishing the samples harvested at successive stages of maturity, and those grown with controlled application of fertilizer, is acknowledged.

[1]Mention of trade names does not imply endorsement by the U. S. Department of Agriculture.

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Recent Results of Rice Protein Supplementation

M. C. Kik*

Studies on the nutritional improvement of rice diets were continued during the past year. Results are presented of *ad libitum* and paired feeding experiments with albino rats fed diets containing milled white rice, milled white rice flour, whole brown rice and whole brown rice flour as the only source of protein, serving as the control ration.

Data also were obtained of feeding experiments using diets containing rice to which were added small amounts of high protein containing foods, such as buffalo fish, bass, red catfish and white and dark chicken meat.

In one series of experiments, the protein-containing food to be tested was added; this led to a higher protein in the test ration compared with that in the control ration. In another series of experiments, the protein of the test food replaced an equivalent amount of protein in rice or was substituted for it, so as to maintain the same protein level as in the control ration. The higher results obtained with these latter rations are not due to a higher protein level in the rations.

In the paired feeding experiments, animals fed the rice-fish rations received the same amount of food as animals fed the rice rations alone. The protein intake was exactly the same for both control and experimental groups.

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The investigations lasted 70 days, and 12 animals, six of each sex, were used in each experiment. One, 3 and 5 percent of fish and chicken meat were used as supplements.

Results

The results were expressed as average growth per animal during the 10-week experimental period, and the protein efficiency ratios (PER) were calculated from the gain in body weight per gram of protein intake.

The proteins of milled white rice, milled white rice flour, whole brown rice and whole brown rice flour were supplemented by the proteins of buffalo fish, bass, red catfish and white and dark chicken meat. This was shown in both *ad libitum* and in paired feeding experiments.

In addition, 18 amino acids (10 essential and 8 nonessential) were determined in the proteins of buffalo fish, dark and white chicken meat and the results were compared with those previously obtained for the protein of rice. It was found that the proteins of buffalo fish, dark and white chicken meat are higher in all amino acids, especially in lysine, threonine, methoinine and cystine. It is believed that the amino acids are responsible for the supplementary effect of the proteins of buffalo fish and chicken meat for those of rice, since the proteins of the latter are low in these amino acids and it has been shown in previous experiments that rice diets are improved by the addition of lysine and threonine.

Disease and Insect Control Section

L. D. Newsom, Moderator

Transmission of the Hoja Blanca Disease of Rice

Guillermo E. Galvez, H. David Thurston and Peter R. Jennings*

The Colombian Agricultural Program of the Rockefeller Foundation and the Colombian Ministry of Agriculture in 1958 initiated a cooperative research program in rice. Certain basic studies on hoja blanca, a virus disease of rice, were begun to complement the breeding work. This report summarizes the data obtained from the study of transmission of this disease in rice.

Hoja blanca is not transmitted to rice by soil, from seed or by mechanical means. Transmission is effected only by insects of the Delphacidae. Male and female adults and nymphs of *Sogata orizicola* transmit the virus from rice to rice and from rice to *Echinochloa,* (barnyardgrass), but not from *Echinochola* to *Echinochloa* nor from *Echinochloa* to rice. Only about 10 percent of the wild population has the ability to transmit the virus.

S. cubana, a related species is involved in infection of grasses. It infects *Echinochloa* from rice and from *Echinochloa* but does not transmit to rice. It appears that the grass acts as a biological trap for the virus since neither species transmits from grass to rice.

In addition to the transmission from rice to rice and to *Echinochloa, S. orizicola* transmits the virus from rice to *Leptochloa* sp., *Digitaria* sp., wheat, barley and oats. It will not transmit to sugar cane, corn or sorghum. *S. cubana* only transmits from rice to *Echinochloa* among these numbers of the Gramineae.

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Transmission and Host Range Studies on Hoja Blanca

H. A. Lamey, W. W. McMillian and J. U. McGuire, Jr.*

Cooperative studies on hoja blanca were conducted at Camaguey, Cuba, by USDA personnel of the Crops and Entomology Research Divisions. Transmission was studied to determine methods of screening rice selections for resistance to hoja blanca. Preliminary data indicated that *Sogata orizicola,* insect vector of the hoja blanca virus, may survive limited periods at freezing temperatures. On the basis of these findings, laboratory experiments were conducted to determine whether the virus and insect vector might overwinter in the United States on plants other than rice.

Attempts were made to transmit the virus mechanically to susceptible rice, Samsun tobacco and *Nicotiana glutinosa.* Sap of diseased leaves was expressed by grinding in a 0.1 M solution of disodium phosphate or sodium sulfite, or both. The expressed sap was wiped on leaves of healthy plants previously dusted with 600 mesh carborundum or injected into the leaf midrib of healthy plants by use of a fine capillary tube. A tissue wipe technique also was used. In this technique, the freshly cut edges of diseased leaves were wiped over the surface of carborundum-dusted leaves of healthy plants. No hoja blanca was transmitted by any of these methods, nor by transplanting excised bits of diseased tissue into healthy plants. No definite evidence of seed transmission was observed in a test of 916 seed from diseased rice plants.

Transmission by the insect vector was studied intensively. Although many techniques were tried, only two gave high enough infection levels to be useful for screening rice selections for resistance to hoja blanca. One of these techniques involved the use of insects from a colony with a high percentage of transmitters. A group of several insects and a young test plant were caged in a glass tube. Test plants were changed twice daily. A known susceptible rice variety was used periodically to determine if any of the insects in the group were transmitting. Results from insect groups demonstrated to be transmitting were fairly reliable but the technique was laborious. The other technique involved placing plants in a large screened cage containing a high population of insects with average transmitting capabilities. If plants were left in the cage more than 2 weeks, insect feeding caused severe plant in-

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jury and often death. Usually the injured plants would not develop symptoms of hoja blanca. If plants were left in the large cage less than 2 weeks, then removed and sprayed with malathion, no more than 40 percent of the plants would develop symptoms. If plants were placed in the cage for several days to a week on 4 to 6 different occasions over a period of several months, all susceptible plants could be infected. This technique was used to test some rice selections. With proper susceptible check plants, the method is relatively accurate and the simplest available at present.

To improve methods for screening rice selections in the field, a test was made to determine the optimum distance between plants for maximum disease development. The highest seeding rate gave the poorest disease development, while the lowest seeding rate (all plants 1 foot apart) gave the best disease development. If plants were at least 6 inches apart, the disease reaction of individual plants could be observed easily.

Studies of the host range of the insect vector indicated that it prefers rice, but can survive for short periods on Cuban corn, Victoria oats, Chapel Hill rescuegrass and Lee wheat; for moderate periods on Kindred barley, Merced rye and sweet sorghum; and for long periods on only commercial ryegrass and rice. Egg laying on rye was approximately half that on rice and negligible on all other hosts. The insect vectors completed their life cycle on rye in the laboratory, but did not reproduce sufficiently to compete with predators in large cages outside.

Feeding by viruliferous insects induced hoja blanca symptoms frequently in rye, occasionally in barley and rarely in oats and wheat. Virus-free insects which fed first on diseased rye and then on healthy rice transmitted the virus back to rice in three of four attempts.

Hoja Blanca Studies at Camaguey, Cuba

W. W. McMillian, J. U. McGuire, Jr. and H. A. Lamey*

Preliminary test of *Sogata orizicola* Muir collected from a normal field population at Camaguey, Cuba, revealed that only 10 to 15 percent were capable of transmitting the hoja blanca virus. After 9 months of selection and cross-breeding, the transmitting ability of these insects reached 75 percent. Further investigations revealed a tremendous amount of transovarian transmission at this time.

S. orizicola males live an average of 24 days while the females live an average of 30 days. Females mate 3 days after reaching the adult stage of development, and lay an average of 161 eggs which hatch in 8 to 11 days. It takes 13 to 14 days for the nymphal stage.

Adult *S. orizicola* were caged on diseased plants for 12 hours before 100 percent acquired enough virus to infect plants. The virus must be incubated for at least 6 days in the adult before it can infect another plant. The vector must be caged on healthy plants for at least 24 hours before 100 percent are able to infect.

When viruliferous insects were fed at three locations on plants of a susceptible variety of rice, ranging from 2 weeks to 3 months old, the appearance of disease symptoms varied from 6 to 34 days.

Field tests with susceptible varieties of rice have shown that the loss in panicle weight ranged from 22 to 82 percent, depending on the age of the plant when infection occurred. Low milling quality further increased the total loss.

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Hoja Blanca and Its Vector Found in Several Louisiana Parishes in 1959

J. G. Atkins, L. D. Newsom and G. D. Lindberg*

Surveys for hoja blanca and its insect vector, *Sogata orizicola,* were planned and conducted by the Crops Research and Plant Pest Control Divisions, ARS, U. S. Department of Agriculture, the Louisiana Agricultural Experiment Station and the Louisiana Department of Agriculture.

Hoja blanca was first identified on August 3 on rice in St. Tammany parish in fields from which the insect vector had been collected on July 23. Later, hoja blanca and/or the vector were found in a total of 14 parishes. These were St. John, St. James, Iberville, Lafourche, Terrebonne, Assumption, Ascension, St. Mary and St. Martin in the river and Teche sections; St. Landry, Evangeline and Vermilion in the southwest section; and Madison Parish in northeast Louisiana. The vector, but not the disease, was found in Evangeline, Vermilion and St. Martin parishes.

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Ecology of Sogata orizicola Muir

J. U. McGuire, Jr., W. W. McMillian and H. A. Lamey*

The subjects considered in this paper are the environment of the egg and the feeding habits and population dispersal in the nymphal and adult stages of *Sogata orizicola* Muir.

The eggs usually are laid in the midrib of the rice leaf. Eggs laid in any other location do not develop properly. In preliminary experiments, all eggs died at a temperature of 43° F. In Cuba, the egg parasite *Anagrus* sp. controlled the insects at certain times of the year. Other

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predators and parasites are *Forficula* sp. and predaceous mites.

The nymphal stages are the most vulnerable in the life history of the insects. Rain and heavy winds take a heavy toll of the first stage nymphs. The older nymphs are better protected in the central region of the plant. Nymphs are able to withstand temperatures below freezing for 24 hours. Eight percent of the nymphs subjected to 21 degrees F. for 24 hours survived the treatment. Several predators and parasites are known—spiders, ants and Dryinids.

Adults in young populations consist of brachypterous females and alate males, while in older populations both sexes are alate. Wind and flowing water facilitate the spread of individuals throughout a rice field. There are indications that dispersal flights may occur at twilight. Temperature reactions of adults are the same as those described for the nymphs. Predators and parasites are the same as for nymphs with the addition of lady-bird beetles and strepsypterans.

A Progress Report on Blast in Louisiana and Texas

G. D. Lindberg and J. G. Atkins*

Blast has been one of the more important rice diseases in the Southern States, particularly in Louisiana, in recent years. Occurrence and damage have been somewrat erratic and localized, depending on cultural and environmental conditions, variety and stage of plant growth. Rice plants are more susceptible in the seedling and early tillering stages. At heading, the top node, internode and branches of the panicle are susceptible, with infection resulting in "rotten neck." A high relative humidity together with free moisture on the rice plants for several hours provide favorable conditions for infection and spread by the fungus. Such conditions generally prevail during July and August when frequent light rains and nightly dews result in water drops being retained on the leaves for about 12 hours each day. The severity of infection varies directly with the nitrogen level in susceptible varieties. Thus, infection, spread and severity of blast depend on the interaction of several factors.

Several rice varieties and selections were tested in 1959 for blast reaction in Louisiana and Texas in special tests under conditions likely to induce disease development. These were the inclusion of highly susceptible varieties, an early June seeding date and a delayed initial irrigation with early heavy nitrogen fertilization. Marked differences in blast reaction were obtained. For example, Calrose, a California variety, was killed out in the test plots, but Zenith, Gulfrose and Lacrosse were unaffected. However, strains of the blast fungus do occur to which these varieties are susceptible.

Since Japanese workers have reported control of blast by using phenyl mercuric acetate, the chemical was tested in 1959 as a spray treatment. The chemical was tested at two dosages and at one and two applications prior to and following heading. Some reduction in "rotten neck" resulted, but the tests were inconclusive. A residue of mercury was found in harvested samples. In view of the zero tolerance set by the Pure Food and Drug Administration, it seems unlikely this mercury fungicide could be used on rice. However, other fungicides can be tested.

One phase of the blast research program involves greenhouse inoculation of young rice plants at Baton Rouge and Beaumont. The inoculation methods are essentially the same as those used by Dr. Francis Lattrell and co-workers. Spore germination was stimulated by the use of 0.05 percent sodium oleate. Objectives of the work are to determine which races occur in the diseased rice fields and to test varieties and selections for blast reaction. Several hundred samples have been tested for blast reaction using one or more races, but not with all races likely to cause damage in the southern rice states.

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Tests with Systemic Insecticides to Control Leafhoppers on Rice

C. C. Bowling*

Four separate greenhouse tests were conducted in 1958-59 with systemic insecticides used as seed treatment and granular applications to control leafhoppers on rice. Phorate and Di-syston used as seed treatment at the rate of 1 pound toxicant per 100 pounds seed gave effective control of the leafhoppers, *Draculacephla portola* Ball, for 32 days from planting date. Tetram at the same rate was ineffective.

Phorate and Di-syston used as seed treatment at 1 pound per 100 pounds seed were equally effective for 43 days, and Shell S. D. 3562 was ineffective in the second test.

Di-syston applied as a 5 percent granular at the rate of 2 pounds toxicant per acre was most effective when applied to dry soil and flushed. Di-syston and phorate applied as a 5 percent granular at 2 and 4 pounds per acre were equally effective for 22 days from date of application. At the 4-pound rate, they were effective for 36 days from application date.

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Control of Grape Colaspis and Rice Water Weevil by Soil or Seed Treatment

L. H. Rolston*

The grape colaspis is sometimes responsible for serious plant stand reductions in rice fields. Larvae of this insect overwinter in the soil and may destroy seedling rice

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in the spring. Overwintering larvae usually are most abundant following lespedeza, although other legumes and weeds also are hosts.

The number of overwintering larvae present at planting time is not a reliable indication of the plant stand loss that may be expected.

A seed treatment of ¼ pound of aldrin per bushel of seed controls both the grape colaspis and the rice water weevil.

Control of both insects increased average yield on eight farms by 6.9 percent in 1958, and by 5.4 percent on 16 farms in 1959.

Rice Stink Bug Studies

L. D. Newsom*

Yield of the varieties Nato and Zenith were decreased about 40 percent by the rice stink bug, *Oebalus pugnax* (F.), in a cage test during 1959. Grade was severely affected by "pecky" kernels resulting from stink bug feeding. This caused a decrease in value of the infested grain.

Two levels of infestation, 500 and 250 adults, respectively, per cage 4 feet square and 5 feet tall, were compared with an uninfested check. These levels of infestation were comparable with the heaviest ever observed in the field in Louisiana. Plots were infested when the panicles began to emerge.

Organophosphorus insecticides were more efficient for control of the rice stink bug than the chlorinated hydrocarbon insecticides in both laboratory and field tests during 1958-59. Topical application of insecticides to individual adult insects showed that there was much more variability of response to dieldrin and toxaphene than to malathion in the populations studied. Seasonal tolerance to the chlorinated hydrocarbon insecticides was much more pronounced than to the organophosphorus materials.

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Cultural Practices, Soils and Physiology Section

Francis J. Williams, Moderator

Evaluation of Herbicides for Control of Echinochloa crusgalli in Water-planted Rice

Kenneth L. Viste*

Several herbicides have been evaluated for controlling watergrass, *Echinochloa crusgalli* in water-planted rice. Of chemicals applied to the dry soil prior to planting in 1958, only ethyl di-n-propylthiol-carbamate (EPTC) was selective. One lb/a of EPTC gave excellent control of watergrass and permitted the highest yields of rice. Moderate injury to rice occurred at 2 lb/a and severe injury and significant reductions in yield resulted from 4 lb/a. EPTC was less effective when treatments were applied to wet soil after an irrigation. Under those conditions, 4 lb/a were necessary to control the grass. On the wet soil, 2-chloro-N,N-diallylacetamide (CDAA) was effective in controlling grass at 4 and 8 lb/a, which did not injure rice. In these experiments, isopropyl N-(3-chlorophenyl) carbamate (CIPC) and 2-chloroallyl diethyldithiocarbamate (CDEC) were not selective. Although they provided some control of watergrass, they reduced the rice stand. 2,4-dichlorophenoxyethyl sulfate (sesone) and 4,6-dinitro-o-sec-butylphenol (DNBP) did not control weeds or injure rice.

Greenhouse evaluation of EPTC and three analogues show that these compounds of this group exhibit selectivity between rice and watergrass and that the chemicals differ in selectivity. EPTC gave the highest degree of selectivity with a value of 7.8 for the ratio of the ED_{50} for rice to the ED_{50} for grass. (The ED_{50} is the concentration of the herbicide in the soil which reduced fresh weight at 6 weeks by 50 percent.) Similar values for the analogues are n-propl di-n-propylthiolcarbamate (R1607) 6.8; ethyl ethyl-n-butylthiolcarbamate (R2060) 2.4; and n-propyl ethyl-n-butylthiolcarbamate (R2061) 3.0. A field experiment with the same chemicals in 1959 gave similar results.

Methods of application were investigated in 1959 by applying granules and sprays of EPTC at rates ½ to 4 lb/a, followed by harrowing, disking or no incorporation. All treatments provided such good control of the watergrass that differences between incorporation methods were not significant. Injury to rice, with reductions in yield, resulted from 2 and 4 lb/a rates with both incorporation treatments, but from only 4 lb/a without incorporation. Spray reduced yields more than granule applications followed by disking or harrowing, but surface-applied spray and granules did not differ.

The experiments reported show that EPTC provides some selectivity between rice and grass and that incorporation increases the effectiveness of this herbicide.

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Weed Control in Row Crops Grown in Rotation with Rice

H. R. Hudgins and Ercel Jeter*

There is increasing interest among rice farmers to produce a cash crop on idle rice land. Varieties and cultural practices necessary for the successful production of corn and grain sorghum are being studied at Substation No. 3 of the Texas Agricultural Experiment Station, located in the rice area near Angleton, Texas. One of the major problems encountered on rice soils is the control of weeds and grasses.

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TABLE 1. 1959 WEED CONTROL TEST—CORN

Treatment[1]	Chemical	Rate, pounds mat./acre	Pounds of ear corn per/acre, average of 4 replications
	NON-FERTILIZED		
1	Control, cultivated		900
2	Control, non-cultivated		710
3	Eptam	6	1440
4	Simazine, cultivated	4	1820[2]
5	Simazine, non-cultivated	4	1870[2]
6	Zytron	8	1470
	FERTILIZED—90-30-0		
7	Control, cultivated		1890[2]
8	Control, non-cultivated		1420[2]
9	Eptam	6	2240[2]
10	Simazine, cultivated	4	3090[2]
11	Simazine, non-cultivated	4	2940[2]
12	Zytron	8	2620

[1]Treatments 1 and 7 received three cultivations. Treatments 2, 5 and 11 received no cultivations. Treatments 3, 4, 6, 9, 10 and 12 received lay-by only.
[2]L.S.D. 5%—848.5 pounds.

Cooperative studies were initiated to test the most promising herbicides for chemical control. One experiment on corn and another on grain sorghum were conducted using three herbicides, combined with fertilizer rates and conventional culture used in the control of weeds and grasses. The herbicides are: *Eptam* (Ethyl-di-n-propylthiolcarbamate), *Simazine* (2-chloro-4, 6-bis (ethylamino) -S-triazine) and *Zytron* (O-(2-4-dichlorophenyl) O-methyl isopropyl phosphoromidiothioate).

In general, the results indicate that simazine controlled the grass and weeds in the test plots through harvest, a period of approximately 16½ weeks. Zytron plots were free of weeds and grass for the first 4 weeks and Eptam plots for the first 3 weeks. The plots treated with Zytron and Eptam were covered with weeds and grass at harvest time.

TABLE 2. 1959 WEED CONTROL TEST—SORGHUM

Treatment[1]	Chemical	Rate	Pounds of grain per/a, average of 4 replications
	NON-FERTILIZED		
1	Control, cultivated		2600
2	Control, lay-by only		2340
3	Eptam	2	2710
4	Simazine	2	3510[2]
5	Zytron	8	2500
	FERTILIZED—90-30-0		
6	Control, cultivated		4020[2]
7	Control, lay-by only		4170[2]
8	Eptam	2	4590[2]
9	Simazine	2	3960[2]
10	Zytron	8	4410[2]

[1]Treatments 1 and 6 received three cultivations. All other treatments received a lay-by only.
[2]L.S.D. 5%—879.7.

The materials used, rates, fertilizer application and yield of grain are shown in Table 1 for corn and Table 2 for the grain sorghum test.

Experimental work with chemical control of weeds and grasses in row crops this year include: comparison of band over the row, broadcast treatment, rate of application, effects of soil type experiment and comparison of chemical materials both new and older established herbicides.

Controlling Barnyardgrass in Rice in Arkansas

Roy J. Smith, Jr.*

Chemical and cultural methods of controlling barnyardgrass in rice were evaluated in combination. In Arkansas, barnyardgrass reduces yields of rice on a large acreage each year.

Isopropyl N-(3-cholorophenyl) carbamate [CIPC] was superior to other chemicals for controlling barnyardgrass in rice. CIPC was more effective at rates of 6 and 8 pounds per acre than at rates of 4 and 10 pounds.

CIPC causes least injury on rice drill-seeded at a depth of 1 to 2 inches, but it injured rice seeded ½ inch deep severely. Drill-seeded rice was injured less than broadcast-seeded.

Maximum control of barnyardgrass and minimum injury to rice were obtained by applying CIPC when the barnyardgrass was emerging through the soil, but before it was beyond the first-leaf stage. At this time, the rice ranged from pre-emergence to emergence. Barnyardgrass in the second or the third-leaf stage was difficult to control.

Water management was critical when the soil surbaked soon after herbicidal treatment; under this condition, irrigation was essential for satisfactory control of barnyardgrass. Rice seeded 1 to 2 inches deep and irrigated soon after spraying with CIPC was not injured.

Ground application of CIPC in a total solution of 10 to 40 gallons per acre satisfactorily controlled barnyardgrass in rice. Airplane application of CIPC in a total solution of 10 gallons per acre also gave satisfactory results.

The efficiency of CIPC at 6 to 8 pounds per acre for controlling barnyardgrass in rice was greater on a Crowley silt loam than on a Sharkey clay. CIPC, however, controlled barnyardgrass satisfactorily on both soil types.

Rice was injured by CIPC when its roots were located in the treated area. The main basis of selectivity of rice and barnyardgrass appeared to be differential depth in location of feeding roots in the soil. Rice was protected from CIPC injury by deep seeding.

Certain new herbicides show promise for controlling barnyardgrass in rice. Among these are 3,4-dichloropropionanilide, 0-2,4-dichlorophenyl 0-methyl isopropylphosphoroamidothioate and 3-amino-2,5-dichlorobenzoic acid.

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Soil and Water Research for Growing Rice

Lewis W. Erdman*

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Rice research at the U. S. Salinity Laboratory was reported under three headings: (1) *Tolerance of rice to salinity*: Six varieties were germinated at salinity levels of 0, 10 and 20 mmhos/cm, and 12 days after planting the initial salinity levels were changed to 0, 3 and 6 mmhos/cm. It was found that the 12-day change over was too late to prevent permanent damage. In another experiment, the change over was made at five different times (0, 2, 4, 8 and 12 days). The results indicated that rice was not permanently damaged if it was changed to a lower level of salinity by the fourth day after planting. (2) *Relative salt tolerance of six additional varieties;* where Agami Montakhab I, Kala-Rata, Asahi No. 1, Norin No. 18, Blue Rose and Century Patna 231 were found to be salt sensitive: (3) *Reclamation of salt-affected soils*: If water of low salt content is available for leaching, it is possible to grow an economic crop of rice in the ponds during the reclamation process. Relatively salt tolerant varieties should be used and, depending upon the amount of salinity, the field may be planted with seed or 4 to 6-week-old seedlings.

Continued research with plastic levees should prove to be a big step forward in the more economical production of rice. Problems which need further study involve selection of a plastic formulation that can fully resist prolonged exposure to sun and temperature variations, developing an improved method of supporting the film on stakes and mechanization of both the placement and removal operations.

Soil and Water Conservation in Texas

For some time, the Texas Agricultural Experiment Station has been interested in rice irrigation studies and particularly investigations to determine evaporation, transpiration and seepage losses of water from rice fields in Texas. A cooperative project was drafted in 1955 involving the Texas Station, Board of Water Engineers and ARS, USDA, with objectives of getting more information to understand better the soil and water relationships in the production of rice.

Unfortunately this work did not go forward as fast as anticipated mainly because of the resignation of one of the key men. However, the work still needs to be done and we are hopeful that time, money and personnel will be available shortly to pursue this research. Further recognition of this need is given in Senate Document 59, "Facilities should be provided for an expanded program of soil and water management research on lands used for rice."

Water Seeding of Rice in Arkansas

Vernon L. Hall*

The practice of water-seeding rice is not new, but it has been used to such a limited scale in Arkansas that information about seeding rice in water is not well known over the State.

There are two general areas of rice production in Arkansas: terrace, which is characterized by a silt loam soil, and bottomlands, characterized by clay or clay loam soils. These latter soils are, in general, wet bottomland soils, difficult to manage but have a high fertility level.

The difficulty in management of the bottomland soils consistently perpetuates a serious problem of establishing a stand of rice without water or barnyardgrass. Seeding rice in water has proved effective for grass control. For this reason, there has been increased interest about water-seeding where the bottomland soils occur. This paper will endeavor to bring out the suggested points for establishing a stand of rice with a minimum of grassy weeds.

Land Preparation

Once the land has been leveled, a disk harrow is effective in preparing the seedbed. Usually the area is covered twice. On the last trip over a spring-tooth harrow follows the disk so that prominent harrow marks are left in the seedbed. These marks will catch the seed and reduce drift. Often, fields so prepared appear to have been planted with a seed drill.

Flooding the Land

The field should be flooded as rapidly as possible and the highest places should be covered with at least 4 inches of water. For grass control, 4 to 6 inches of water are recommended, with the latter depth being the most successful.

When water-seeding, the levees will need be broader and higher than those normally used. All levees should have a gate or spillway that will maintain a constant level of water and prevent the levees from breaking due to heavy rain.

Seeding

The field should be seeded immediately after the 4 to 6-inch depth of water is obtained. The recommended rate of seeding is 3 bushels (135 pounds or 0.83 barrel) per acre. There has been some question about stirring up the water so that it is muddy at the time of seeding. Our findings are that there is no significant difference in plant stand density due to seeding in clear or muddy water that cleared soon (within 24 hours) after seeding. Presoaking the seed showed no significant difference from seeding with dry seed. However, presoaked seed will not float on the water as do dry seed. Seed treated with a fungicide, insecticide, or both, will sink better than untreated dry seed.

Water Management

After seeding, the full flood of 4 to 6 inches of water should be maintained for 5 to 6 weeks. There has been some concern about wave action floating the plants to the levees. To reduce the amount of plant movement, fields are often drained. To lower the depth of water or drain the field will allow grass to become established with the rice, thus, defeating the purpose of water-seeding. Our information to date indicates that a seeding rate of 3 bushels per acre gives sufficient plants that the loss due to wave action is much less than loss from weeds due to draining the field.

After about 6 weeks from planting, the field may be drained for midseason nitrogen fertilization.

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Response of the Rice Plant to Temperature, Photoperiod and Light-intensity

D. P. Ormrod*

The responses of rice plants to environment are of particular importance in California. Air and water temperatures may be too low for early seedling growth, and some areas have a cold-water problem throughout the growing season. Late in the season, air temperatures may become too low for adequate seed set. The long photoperiod in midsummer delays the heading of almost all varieties. Low light intensity may be a problem early in the growing season if skies are overcast for extended periods.

Temperature effects are under investigation in several ways. Cold-water effects are being studied by testing seedlings up to 1 month old in a controlled-temperature chamber, and testing plants throughout the growing season in field trials in cold-water areas. The effects of several levels of water temperature are being studied in concrete cylinders, placed at soil level, through which cooled, warmed or untreated water is circulated. Low-temperature effects on seed set are being studied in a larger chamber, in which potted mature plants can be subjected to specific cold treatments.

Experiments with controlled photoperiod chambers have indicated that rice varieties vary greatly in their sensitivity to daylength above the optimum, and that this sensitivity is related to their field maturity dates. For instance, an early variety (Colusa) is less sensitive to photoperiod than midseason variety (Caloro). A late variety (TP49) is highly sensitive to photoperiod and does not head until the days become much shorter.

Studies were made in a controlled-environment chamber of how photosynthesis rates are affected by various temperatures (40 to 80° F.) combined with various light intensities (0 to 6000 foot-candles). The plants used were 3-½ to 5 weeks old. Carbon dioxide exchange rates were measured with an infrared gas analyzer. Net photosynthesis in light was appreciable even at 40°, and was generally highest at 60°. A lower rate of 80° appeared to be due to a much higher respiration rate. The compensation points were about 150 foot-candles at 40°, 400 foot-candles at 60° and 1400 foot-candles at 80°.

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Gulf Ryegrass in Rice-Pasture Cropping Systems

R. M. Weihing*

Annual ryegrass, *Lolium multiflorum* Lam., is marketed under various names such as annual, common, domestic, Oregon or Italian. Its many uses include pasture, silage, hay, seed, erosion control, green manure, bloat control, winter lawns and winter golf greens. Rice farmers have begun to use this grass in rice-pasture cropping systems, especially the winter-productive, rust-resistant variety Gulf. The rust resistance of Gulf assures a seed crop every year. In addition, Gulf ryegrass has been nearly twice as productive in early winter as domestic or common ryegrass. It is now available in the seed trade. This report reviews 12 years of research with ryegrass at Beaumont, Texas, on two soil types, both low in available nitrogen and P_2O_5.

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Seeding Practices

Ryegrass was seeded from early September to mid-December. Early seedings were ready to graze by November, the late seedings by February and March. A September 15, 1959 seeding produced 1,300 pounds of dry matter by November 11, a November 9 seeding produced 1,000 pounds by February 2.

Good stands were obtained from 10 pounds of seed per acre broadcast or drilled on prepared seedbeds or broadcast in rice-stubble. Broadcasting or drilling in sod was delayed until early November.

Volunteer stands were obtained in the fall from seed dropped to the ground the preceding spring. Working the land in late summer improved the volunteer stand.

Fertilization

Ryegrass can utilize generous amounts of nitrogen for fall, winter and spring growth. Approximately 30 pounds a month should be available during the growing season for lush growth. Herbage yields decrease as available nitrogen decreases. Slow growth in winter may be nitrogen deficiency rather than cold weather. The nitrogen can be furnished from commercial fertilizer or from legumes grown with the grass. Dry matter yields from November 11 to April 25 for seven cuttings in the 1959-60 season totaled 7,600 pounds per acre. Fertilization was 150-60-0. The nitrogen was applied in five 30-pound increments on these experimental plots. Protein in the dry forage has ranged from 25-33 percent in December to 15-19 percent March 1.

Liveweight beef gains per acre were 530 pounds from December 4 to June 1 during the 1958-59 season. Fertilzation was 0-40-0. The grass seed were broadcast October 15 on a prepared seedbed on improved pasture land. White and Persian clover volunteered. An excellent mixture of grass and clover was available throughout the grazing season.

Pasture

Gulf ryegrass has been grazed the past 3 winters. Seedbeds were prepared in late summer or fall on land that had supported reseeding clovers (white and Persian) for several years. Ryegrass seed were broadcast at 10 pounds per acre. Clover was not seeded, but re-established every year from hard seed. Liveweight beef gains for yearlings were 385 pounds per acre from March 10 to May 21, 1958, and 530 pounds from December 4, 1958 to June 1, 1959. Fertilization was 0-40-0 in both cases. A 5-year-old improved pasture, plowed in August 1959 for rice in 1960, was drilled to ryegrass October 8. No fertilizer was used. Liveweight beef gains for yearlings were 115 pounds per acre from December 9, 1959 to April

23, 1960. The land was worked to plant rice in late May. These gains were made during the coldest winter in the 46 years of records. Monthly mean temperatures were 6, 2, 5, 9 and 8° F. lower than the 46-year average from November, December, January, February and March. Two other fields drilled October 8, 1959 without clover were furnished 75 pounds per acre of N from ammonium sulfate in two or three increments after December 1. These provided grazing for one yearling per acre in February and March. Average daily gains per yearlng were 1.75 pounds for the 2 months. Liveweight gains per acre were 172 pounds from January 20 to April 23. The early removal of cattle permitted preparation of the land for planting rice in late May. Typical daily gains for yearlings on ryegrass-clover pasture have been 1 to 2 pounds in January, February and March and 3 pounds in April.

Cropping Systems

Typical cropping systems that include rice and cattle could be (1) rice every year with ryegrass in winter; (2) 2 years rice—3 years improved pasture; (3) 2 years rice—4 years improved pasture; (4) 3 years rice—5 years improved pasture. In the last three systems, the improved pastures of Dallisgrass and clovers (white and Persian) were plowed in the summer preceding the first rice crop, the land leveled and leveed by fall. Volunteering of reseeding clovers was abundant. Clover alone was ready to graze by late February in favorable seasons and late March in cold winters. However, ryegrass seeded on this land in mid-October can be grazed by December 1 and, at times, will reduce bloat from clovers in late February and March. Residual nitrogen from the pasture is adequate most years until volunteer clover becomes established. When the improved pasture has been fertilized adequately, no additional fertilizer is needed.

The past 2 years, N. S. Evatt has drilled rice in ryegrass sod. The forage was removed by mowing for hay or silage. Drilling of rice without seedbed preparation followed immediately. Slightly lower but satisfactory grain yields, as compared with those from a regularly prepared seedbed, were obtained in 1959, despite some early seedling death probably due to poor soil contact. A good stand developed in 1960. Indications are that yields will be essentially the same as those on regularly prepared seedbeds. This practice conceivably offers promise from the standpoint of more efficient land utilization and lower producton costs.

Silage and Hay

Gulf ryegrass-clover mixtures have been utilized for silage and hay. Average yields were 3 tons per acre of hay or 10 tons of silage. Protein was only 6 percent in an almost pure stand of ryegrass ensiled in 1957. This contrasts with 14.7 and 12.5 percent in 1958 and 1959 for ryegrass-clover mixtures. Cows with nursing calves were self-fed the past 2 winters on ryegrass-clover silage with good results.

Seed Production

Seed yields of 400 to 800 pounds per acre have been obtained by seed growers. Some fields grazed until early March yielded 700 pounds in 1960. Thirty to 60 pounds of nitrogen per acre may be needed March 1 for a good seed crop when the grass is grazed heavily during the winter or if the winter growth has been removed by mowing. Over 3,000 pounds per acre of dry matter were removed in four cuttings by March 1. Yet seed yields exceeded 900 pounds per acre and straw yields 1.5 tons. Over 6,000 pounds of dry matter were removed in six cuttings from November 11 to March 28 the winter of 1959-60 followed by a May harvest of 558 pounds of seed and 1 ton of straw. The straw usually is baled and fed free-choice to cattle on clover pastures in the winter. It contains about 3.5 percent protein.

Drying and Storage Section

E. B. Kester, Moderator

Receiving Rice by Farm Truck

Whit O. Slay and Reed S. Hutchison*

Four principal methods are used to raise trucks or truck beds to empty rice from them: self-dumping trucks, a hook hoist arrangement, a cradle hoist arrangement and a hydraulically-hoisted platform. The method by which the truck or bed is raised is used to designate the method of receiving.

The receiving cycle is divided into four major operations of setup, weigh, dump and sample. These operations are further subdivided into time items to determine labor requirements.

Many different combinations of equipment and methods are used in the industry. For this reason, specific methods and equipment are compared in the discussion on handling equipment and methods variation.

For an annual volume of 2,000 truckloads of rice received by the four methods, costs are:

METHOD	COST PER TRUCK
	Dollars
Self-dump	1.7578
Hook hoist	1.8546
Cradle hoist	1.8665
Hydraulic hoist	2.3214

The difference in cost of each method is due entirely to equipment. This is because the capacity of the receiving leg and its attendant handling equipment determines the labor cost. Most receiving legs are 11 x 7 in size and require 7 minutes to remove the average load of 14,000 pounds of rice from the pit. The necessary labor to receive a truck can be performed in much less time than this. Thus any equipment that is faster than another type in some other part of the receiving cycle merely extends the wait for pit to empty time.

An improved method utilizing a size 14 x 7 receiving leg, a 16-inch conveyor and other related handling equipment is compared with the average method. For an

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annual volume of 2,000 truckloads of rice received by the improved method, the costs are:

METHOD	COST PER TRUCK
	Dollars
Self-dump	1.6412
Hook hoist	1.7707
Cradle hoist	1.8150
Hydraulic hoist	2.2800

The savings per truck range from 0.04 to 0.11 cents. The possible rate of receiving increases from 28 percent by the hydraulic hoist method to 134 percent by the self-dump method, as compared with average methods.

The self-dump method is the best of the four ways studied to receive rice, but it would take a strong educational program to have all trucks converted to self-dump. The hook hoist method is next best, but it also will require an educational program to influence truck owners to hinge the beds. The benefits, however, apparently are worth the effort involved. The hydraulic-hoist method is the most expensive, but is more versatile, since it can dump farm trucks and tractor-trailers in the same amount of time.

Use of more than a two-man crew is unnecessary since all labor performed in receiving one truck is done in less time than it takes to empty the pit.

Comparison of Rice Drying Temperatures and Techniques

Xzin McNeal*

The rate of rice drying was increased markedly as the number of dryings was increased. When the drying temperatures were raised from 120 to 135 and 150° F., there also was a marked increase in drying rate.

At 120° F., there was a marked increase in head yields as the number of dryings was increased from three to six passes and the moisture contents were reduced from 13 to 10 percent.

At 135° F., there was a marked increase in head yield through the fourth pass (to 12 percent). However, at the fifth and sixth passes there was very little increase.

At 150° F., there was a slight increase in head yields as the number of dryings was increased from three to five passes and moisture contents were reduced from 13 to 11 percent. At six passes and at 10 percent, there was a slight decrease in head yield as compared with five passes.

The one pass, 6-inch pack drying at 120° F. consistently produced lower head yields than rice dried in the multipass systems at temperatures ranging from 120 to 150° F. In all tests, rice that was dried in one pass in thick pack (12 and 18″) at 120° produced relatively low head yields when compared with the various systems of drying.

Germination results were relatively high for the various drying systems used, ranging from 91.17 to 95.89 percent. There was a noticeable decrease in germination of rice dried at 150° F. The number of passes and moisture content (13 to 10 percent) appeared to have had very little, if any, effect on germination.

The major benefit derived from over-drying rice is that it does not appear to deteriorate as rapidly as higher moisture rice and is not as vulnerable to insect attack.

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Rice Drying Research

David L. Calderwood and Reed S. Hutchison*

Research on improved techniques and equipment for drying rice at commercial dryers is being continued in a pilot rice drying plant erected by the Agricultural Marketing Service of the U. S. Department of Agriculture at the Rice-Pasture Experiment Station, Beaumont, Texas.

Tests are being made to determine the effect of the temperature to which rice is heated during passes through the dryer on the market quality. Other factors such as throughput rate, temperature rise of the heated air, tempering treatment and the variety of rice also affect the market quality. With so many variables, a large number of tests are necessary before results can be applied over a wide range of conditions.

Throughput rates of one and two barrels per minute have been used with each temperature treatment. Two tempering treatments have been used and three varieties of rice have been dried.

The usefulness of aeration as a supplemental treatment to drying of rice in heated-air type dryers has been explored. Aeration can aid rice drying in the following ways:

1. Maintain "green" (undried) rice at outside air temperature, thus avoiding heating and rapid deterioration. This allows rice to be held in bulk storage for several days before commencing a series of passes through the dryer.

2. Cool rice to outside temperature during the tempering period between passes through the dryer. Such cooling usually results in a reduction of rice moisture content. It also allows the tempering period to be extended.

3. Cool rice to outside temperature following the final dryer pass and avoid the need for using the dryer or a section of it for cooling.

Green rice was aerated in corrugated steel bins of approximately 250 barrel capacity. Airflow rates in these bins varied from .18 to 2 cfm per barrel. The moisture content of rice varied from less than 18 to more than 23 percent. Although these findings should be considered case studies, they have provided the following indications:

1. Several lots of long-grain rice varieties (Bluebonnet and TP-49), initially less than 21 percent moisture content and aerated at the rate of 0.8 cfm per barrel, were not damaged when held in aerated storage for as long as 11 days.

2. Two lots of medium-grain rice (Gulfrose) initially 21.7 and 23 percent moisture content, respectively, and aerated at the rate of 0.8 cfm per barrel, were not dam-

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aged when held in aerated storage for 3 days. Another lot, initially 22 percent moisture content, and aerated at the rate of 2.00 cfm per barrel for 7 days was reduced in grade from No. 2 to No. 6.

A series of tests indicated that cooling rice to outside temperature by aeration during the tempering period between passes through the dryer resulted in savings of both fuel and dryer operation time. These savings are attributed to the moisture reduction which generally accompanies such cooling and the need for fewer passes through the dryer.

A total of 18 lots of rice was included in these tests. Included were six lots of each of three varieties, Gulfrose, Bluebonnet and TP-49. Nine of these lots were cooled to outdoor air temperature by aeration during all tempering periods between passes through the dryer. The other nine lots were tempered at high temperature. As nearly as possible, extraneous conditions such as variety, initial moisture content, temperature of rice leaving the dryer, through-put rate and final moisture content, were scheduled to affect both treatments equally. The results of these tests are summarized in Table 3.

TABLE 3. COMPARISON OF DRYING COST FACTORS AFFECTED BY METHOD OF TEMPERING RICE

Item	Rice stored at high temp. for 6 to 24 hours	Rice cooled to outside air temp. by aeration	Percent diff.
Av. number dryer passes per lot	4.700	3.600	23.4
Av. gas consumption:			
Gals/barrel rice dried	0.310	0.270	14.7
Gals/cwt. moisture removed	2.280	1.920	15.8
Av. electrical energy consumption[1]:			
KWH/barrel rice dried	0.340	0.350	—2.8
KWH/cwt. moisture removed	2.640	2.520	4.5
Av. dryer operation time (labor):			
Hours/barrel rice dried	0.046	0.038	17.4
Hours/cwt. moisture removed	0.370	0.271	26.7

[1]Includes electricity used during drying operations and also electricity used by aeration fans.

Market quality factors such as percentage of germination, percentage yield of head rice and the grades for these lots of rice followed no trends that appeared to be related to the tempering method.

Observations were made of the times required to cool bins of dryer-heated rice to near outside temperature. Although there were variations in cooling rates due to varying conditions, a typical example was the cooling of a bin of rice from 114 to 84° F. in 25 hours, with an airflow rate of 1 cfm per barrel. Outside air temperature averaged 80° F. The time for cooling in other bins varied with the airflow rate approximately according to the following formula:

$$\text{Cooling time, hours} = \frac{25}{\text{Airflow rate, CFM/barrel}}$$

Field Tests of Protectants on Rough Rice

Elvin W. Tilton*

A large-scale evaluation test of protectants applied to rough rice in bulk storage was conducted in Houston, Texas, from July 1, 1958 to August 6, 1959. Rough rice was moved into the warehouse and treated with malathion, methoxychlor or pyrethrin-piperonyl butoxide. The treatments were made during July 1-August 10, 1958, and the test was terminated August 6, 1959.

The building was a loosely-constructed sheet metal warehouse divided into 55 bins with a common overhead space. The 55 bins were divided into five blocks and various dosages of each treatment were randomized and replicated in each block. Two check bins in each block received only a spray of water equal in volume to that used in the treatment of those bins receiving the protective treatments. Intended deposits for the malathion were 7 and 14 p.p.m. from a wettable powder and 7, 14 and 21 p.p.m. from an emulsifiable concentrate; for methoxychlor, 25 and 50 p.p.m. from a wettable powder; and for pyrethrum-piperonyl butoxide, 3 p.p.m. of pyrethrins and 30 p.p.m. of piperonyl butoxide, or 4 p.p.m. and 40 p.p.m., respectively. The materials were applied at a point approximately 12 feet from the feeder hopper directly onto the rice stream as it moved down the auger.

The rice, aside from addition of the protectants, was handled as it would be in normal commercial storage. As weather permitted, bins were aerated in the normal manner and for approximately the same length of time.

Sampling of the rice was conducted at the beginning and periodically throughout the storage period. At each sampling period, insect population, milling yield, residue deposits on the rough rice and milling fractions, insecticidal activity as determined by bioassay, temperature and moisture level of each bin were determined.

Residue analyses indicated considerably less than intended deposits of malathion and synergized pyrethrins.

Malathion applied to rough rice gave a reasonable degree of protection against insects for 12 months' storage. Wettable powder formulations tended to be somewhat better than emulsifiable concentrates. An application rate intended to give a residue of 21 p.p.m. gave better protection than one that was intended to give a residue of 14 p.p.m., and 14 p.p.m. gave better protection than 7 p.p.m. Residues of malathion on rough rice, rice bran and milled rice never approached the 8 p.p.m. tolerance level.

Methoxychlor wettable powder at intended deposits of 25 and 50 p.p.m. gave erratic protection, failing completely in several cases.

Pyrethrum plus piperonyl butoxide provided a fair degree of protection at the dosages used. To get maximum benefit from this material, a dosage in excess of the ones used in this test would be necessary. The relatively high cost of this material could make it prohibitive. Residues of this material on milled rice were low.

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Some Cooperative Studies on Drying Southern-grown Rice

James J. Spadaro*

The primary objective of the cooperative studies undertaken by the Southern and Western Utilization Research and Development Divisions was to determine the feasibility of applying the WURDD procedures to determine and maintain more efficient rice drying conditions to Southern-grown medium and long-grain rice. The procedures had been applied successfully commercially to short-grain rice in California where both capacity and head yields have been increased. Secondary objectives were to determine whether dryer plant operators could conduct the necessary control tests, to evaluate statistically the sampling and testing methods and to determine the effect of drying rice to as low as 10 percent moisture.

The only equipment used for conducting the drying tests, aside from that normally available in a rice dryer plant, was a rice sample-dryer which contained spaces for 10 trays, each with an area of 1 sq. ft. The rice varieties used in the tests were Zenith (medium-grain) and Bluebonnet 50 (long-grain).

Tests were first conducted at mill A, where three LSU-type dryers were operated in series. Results showed that, with medium-grain rice (Zenith), feed rate could be increased by over 35 percent by using air temperatures of 130° F. in all dryers except for the last pass in the third dryer where cool air was used. Calculations showed that drying costs were reduced by $0.035 per barrel. Small gains attained in milling yields were considered to be within experimental error. With long-grain rice (Bluebonnet 50) fastest drying was achieved when air temperatures of 140° F. were used. Although an increase in capacity of 20 percent was attained, the results were not considered conclusive due to the wide variation in milling results.

Dryer operators were shown how to take samples, how to determine frequency of sampling, how to operate the sample dryer, etc. After the second test run, dryer personnel were conducting the actual tests.

Mill B was more "advanced" from the engineering and mechanical viewpoint which was desirable since emphasis at this plant was placed on evaluation of sampling and testing procedures.

Results of a series of tests conducted on the basis of a statistical design showed that: 1. the variability among samples dried in the sample dryer on the same day is negligible although the variability between samples of the same rice dried on different days (effect of drying days) is detectable; 2. milling results do vary from day to day; 3. there is detectable, sometimes sizable, variability in duplicate samples caught from the process stream; and 4. milling operators may differ from one another though there is some evidence that the variability actually found between operators could be explained by differences in the days that prevailed and the moisture content of the sample they obtained.

This work resulted in the determination of sources of variabilities that tend to effect evaluation of rice drying data, thus enabling the design of a more efficient experimental procedure for studying rice drying.

Seven drying test runs at mill B showed that the plant was operating at near optimum conditions. By varying the drying temperatures and number of passes, rate increases of up to 54 percent were obtained, however, head yields, decreased as much as 3 percent. For example, a 33 percent rate increase resulted in a 1 percent decrease in head yield as compared with the control.

A laboratory-scale study was made at mill B to evaluate the effects of drying rough rice to moisture contents between 14 and 10 percent. Results showed that both head and total yields are affected by the moisture content of the rice at the time of laboratory milling. For example, a 1 percent decrease in moisture showed an increase of 2.1 percent in head yield and 0.7 percent in total yield.

Estimates were made on the possible increased return to a rice miller by reducing the moisture of the rough rice to 10 instead of to 12 percent. Values of $0.09 and $0.05 per lb. were used for head and broken rice. Allowing for additional drying costs and decrease in weight, a mill handling 500,000 barrels of rice could have an additional return of $100,000 annually or an increase of approximately 23.0 cents per barrel. Moisture regain of milled rice back to 12 percent could mean an additional return of $100,000 for a total of $200,000.

To summarize, the studies have shown that: 1. the WURDD procedures can be applied to improve the drying of Southern-grown medium-grain rice; 2. dryer personnel can conduct the necessary control tests to apply the WURDD procedures to improve their rice-drying operations; 3. the use of a more efficient experimental procedure can be used to study rice drying; and, 4. there may be some benefits in drying rough rice to moisture contents below 12 percent.

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Heated Air Drying of Western Rice

Theodore Wasserman*

Short-time Tempering

During drying, moisture removal is rapid at the top of the dryer and becomes slower as rice passes down the dryer. At the same time, internal stresses develop in the kernels and increase as drying continues in any pass. If these stresses become too great, the rice becomes checked or cracked. During tempering, moisture equalizes in the kernels and stresses are relieved. After tempering, moisture removal during drying will again be rapid at the start of the next pass. Thus multiple pass drying with tempering between passes shortens the residence time in the dryer and tends to preserve head yields.

Adequate tempering usually is decided by some vague criterion such as feel or smell, or an arbitrary time limit. For practical purposes, complete equalization of moisture

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is not necessary during tempering. The study reported here was made to determine what tempering time is adequate, using drying time and head yield as criteria. Since operators may or may not cool the rice before tempering, tests were designed to provide information for tempering both cooled and uncooled rice.

Caloro short-grain rice was dried in three passes from 20.1 to 13.0 percent moisture with 110° F. air. Two series of tests were made. In one series, rice was tempered at 105° F. In the other, the rice was cooled with 75° F. air for half as long as the drying period and tempered at 75° F. Tempering times for each series were 0, 4, 8, 16 and 32 hours.

Figure 1 shows the effect of tempering time and temperature on head yield. Four hours were adequate to preserve head yield for rice tempered at 105° F. Six hours were adequate for rice cooled after each pass and tempered at 75° F. Head yields of rice tempered at 105° F. were 2 percent higher than those from rice cooled before tempering.

Figure 2 shows the effect of tempering time and temperature on total drying time. Total drying time includes only the time when heated air was used, and does not include the cooling time. For rice tempered at 105° F., little change occurred after the 4 hours of tempering required to preserve head yield. For rice tempered at 75° F., there was only a 14 percent decrease in drying time when the tempering time was lengthened from 6 hours, the time required to preserve head yield, to 32 hours. Rice cooled and tempered at 75° F. required 40 percent longer heated-air drying than rice tempered at 105° F.

The different tempering methods did not change storage characteristics.

Plant-scale tempering tests confirmed laboratory results. A lot of rice recirculated on a 4-hour tempering schedule was dried and cooled for storage in five passes in an elapsed time of 18-½ hours. This lot required the same drying time and produced the same head yield as a lot dried under the same conditions but with normal tempering periods of 12 to 24 hours.

How Moisture Affects Milling Yields

The USDA official milling appraisal test requires milling in a McGill No. 3 Miller for a definite time. In 1955, milling yields of Caloro rice milled by this method were found to vary inversely with the moisture content in the range 10 to 14 percent. Head and total yields increased 1.8 and 1.2 percent, respectively, for each 1 per-

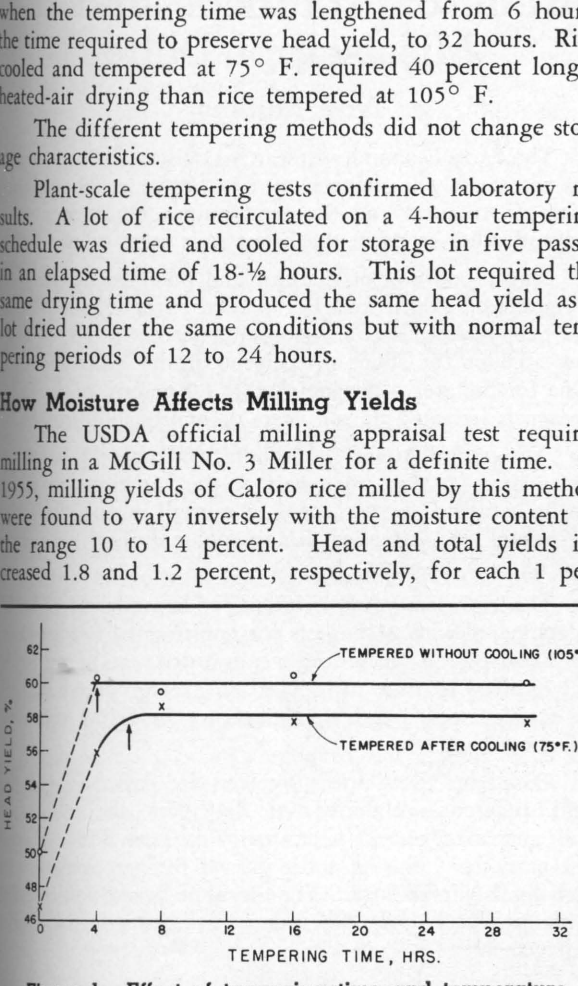

Figure 1. Effect of tempering time and temperature on head yield.

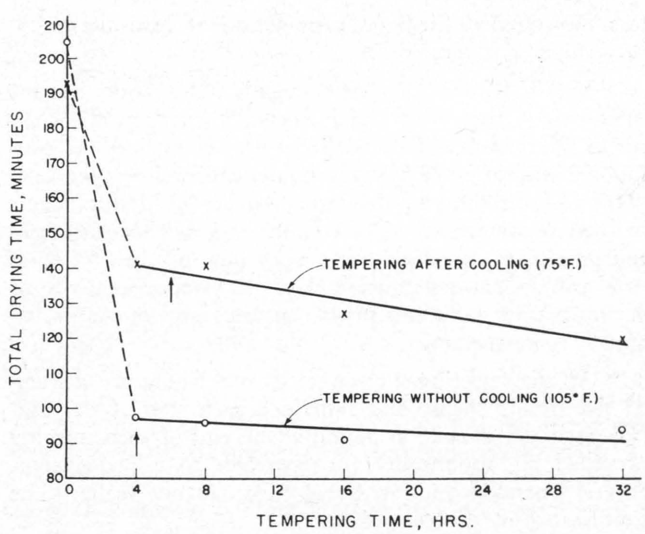

Figure 2. Effect of tempering time and temperature on total drying time. Cooling time not included in drying time.

cent decrease in moisture. The same type of regression was found with Caloro rice in four series of tests which involved four different seasons, two different mills and three different operators. Thus samples for comparison of milling yields, when appraised by the official method, must be at the same moisture content or correction curves must be developed to correct milling yields for moisture content. California grain appraisal laboratories are using a variation of the official appraisal method. The mill is allowed to run until the weight arm drops 2 inches. In this method, moisture content has a much smaller effect on milling yields than in the official method. There is great need for further study of the effect of moisture content on milling yields.

Commercial milling equipment operates differently than the official McGill mill. To determine whether overdrying would result in higher milling yields in commercial equipment, three 4,000 cwt. lots of rice at 13.5 percent moisture were each split into two parts; one part of each lot was dried under mild conditions (two passes with 120° F. air) to 11 percent moisture, and the six half-lots were milled in the plant. Head yields of the rice at 11 percent moisture averaged 3 percent higher than those from 13.5 percent rice. Total yields were not significantly different. However, when weight shrinkage was considered, value of rice dried to 11 percent was 5 cents per cwt. less than the rice at 13.5 percent moisture. If the moisture removed in redrying were replaced, value of the rice dried to 11 percent moisture would be 5 cents per cwt. more. In the limited tests described, overdrying did not offer any economic advantages.

Dissemination of Information

In recent years, we have published a number of papers on improved techniques for drying western rice. Reports of this research also have been presented at various meetings of rice industry representatives. According to reports from operators, our findings are being applied in some form in numerous plants. However, most operators are not making control tests which we have published, and which are required to find the most effective operating conditions for a particular plant. Discussions with operators showed that further dissemination of information on procedures was needed.

The California Warehousemen's Association became interested in this subject and enlisted the aid of the California Agricultural Extension Service in setting up educational meetings. The Warehousemen's Association sent notices of meetings to the large number of drying plants in their organization. The county farm advisors arranged four meetings, notified dryer operators in their districts and presided at meetings. Over 100 representatives of drying plants, including plant managers and operators, attended these meetings.

At each meeting, personnel of our laboratory discussed rice drying theory and explained each step of the control tests. A discussion period at the end of each meeting provided an opportunity for operators to ask questions. Several operators indicated that they had not realized the significance of the control tests.

Many of the questions asked showed that the information given in our publications had not been assimilated fully by plant management and operating personnel.

From this experience, we have concluded that meetings of the type described are needed to supplement published results. This is particularly true in cases when research findings are of use mainly to plant personnel.

Infra-red Drying of Long and Short-grain Rough Rice

Harry W. Schroeder and C. H. Kingsolver*

The drying rates and milling yields in relation to infra-red drying of two varieties of long-grain rice (Rexoro and Bluebonnet 50) and two varieties of short grain rice (Calrose and Caloro) were determined and compared. The effects of initial moisture content and the length of the irradiation period were studied for each variety. The experimental treatments were essentially the same for all four varieties.

All samples were irradiated at a rate of 4,766 BTU input per hour per square foot of irradiated surface as calculated from the rated input of the heater and the total irradiated area. A gas-fired ceramic panel infra-red heater was used as the source of infra-red. All samples were 200 grams (based on the highest moisture level of each variety) and were irradiated in a layer of approximately a single kernel thickness for periods of 5 to 30 seconds.

Drying rates for all varieties decreased as the initial moisture content of the rice was decreased and increased as the irradiation period was increased from 10 to 25 seconds. The drying rates (based on grams of water removed per 10 seconds of irradiation) varied from 0.9 grams for 14.8 percent Calrose to 2.1 grams for 21.6 percent Bluebonnet 50.

The mean yield of head rice did not differ significantly from the controls air-dried at room temperature in 14 of 18 treatments for Rexoro, in 14 of 16 treatments for Bluebonnet 50, in 9 of 15 treatments for Calrose and in 8 of 15 treatments for Caloro. A significant increase in head yield was obtained only with Caloro rough rice at 18.6 percent moisture irradiated for 5 seconds. In general, head yield was reduced by the longer irradiation periods with rice of low moisture content.

Differences between varieties were greater than differences between grain types. The principal difference appeared to be due to the rate of absorbtion of heat energy by the rice. Bluebonnet 50 and Caloro attained higher temperatures in a given irradiation period at identical moisture levels than Rexoro and Calrose.

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Economics and Marketing Section

Troy Mullins, Moderator

Some Factors Affecting Resource Adjustments in the "Old" and "New" Rice Areas of Arkansas and the Mississippi Delta

Troy Mullins*

The Farm Economics Research Division, ARS, is studying enterprise adjustments on rice farms in the old rice areas of Arkansas and the input-output requirements for rice and other crops in the heavy soils areas of the Delta.

The proportion of the cropland occupied by soybeans in the Grand Prairie area has increased from about 20 percent before allotments on rice to 50 percent in 1959. They now account for about 40 percent of the gross farm income for the area. Seventy-five to 80 percent of the total acreage is irrigated during years of appreciable drouths.

The period August 1 through September 15 is critical for soybeans. More than half of the variations in yields can be explained by variations in rainfall during the fruiting period, and extended drouths occur during this period in 6 of each 10 years.

During "dry" years, irrigated fields produced 32 bushels compared with 21 bushels for nonirrigated fields. Over the 5-year-period (including wet and dry years), the fields that received irrigation produced an average of 34 bushels per acre, compared with 28 bushels for fields not receiving irrigation.

Based on 1959 prices received for soybeans and the yield differences obtained for dry years, the returns to land and management from irrigated soybeans averaged $33 per acre. This is above the $6.60 per acre cost of applying 2.3 irrigations. For the same years, nonirrigated fields produced only $16 per acre returns to land and management.

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The annual returns from irrigation during the 5-year-period averaged about $8 per acre. Compared with non-irrigated soybeans, this represents an increase in returns to land and management of a little more than 25 percent.

Although the growing of rice in the Mississippi Delta increased to 0.2 million acres in 1954 (0.1 million acres in 1959), the Delta is a comparatively high-cost production area, and one for which the annual income varies over a wide range.

The amount of labor and tractor time used is about 20 percent higher in the Delta than on the Grand Prairie. Exceptionally heavy equipment is required, which also contributes to high production costs.

The cost of supplying water to rice fields varies a great deal, and depends largely on the source of water. Three-fourths of the rice acreage is irrigated from wells at direct costs averaging slightly less than $11 per acre and overhead costs of about $4 per acre.

In the Delta, water requirements are high because of excess seepage from canals and field levees, and because of the wasteful practices of farmers. Delta rice farmers are inexperienced in levee construction. Some farmers feel also that allowing water to move through their fields is beneficial in the control of scum and other undesirable growths in their rice.

In addition to high costs, the risks associated with establishing good stands, with controlling grass and with carrying the rice through to harvest without lodging are other factors that are difficult to evaluate. The development of effective management systems for rotating rice with other crops or uses may correct these difficulties. The systems now in use are rice 1 to 2 years, then idle or fallow for the same number of years; rice 2 years and soybeans for 2 or more years; and rice 1 to 2 years and water cover for a similar period.

Costs to Dry and Store Rice in On- versus Off-farm Facilities

Job K. Savage*

This is a brief report on a study now in process. Harlon D. Traylor, assistant professor, Department of Agricultural Economics, Louisiana State University, is in charge of work on the project in Louisiana and Texas. He also collaborated with me in preparing this preliminary report.

The purpose of this study is to analyze costs and other considerations in drying and storing rough rice in on versus off-farm facilities. It was formally initiated in July 1959, and is expected to be in progress about 3 years.

This study is being conducted on a joint basis by Farmer Cooperative Service of the U. S. Department of Agriculture and Louisiana State University. The Texas Agricultural Experiment Station also is cooperating on this project together with several other agencies, including the Agricultural Research Service, the Agricultural Marketing Service and the Grading Service of the U. S. Department of Agriculture.

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Important factors being examined in this study include:

1. A measure of the total costs incurred by owners of various types of facilities now in use to dry and store rice, including those costs due to variations in rice quality and value resulting from the drying and storing process.
2. Appraisal of current and future market conditions which may affect the need for facilities to dry and store rough rice.
3. Some examination of the problems associated with sampling and grading rough rice.

Eighty farm units and 24 off-farm units are being studied. Of these, 50 are in Texas and 54 in Louisiana. Questionnaires to obtain costs of drying and storing and related information from the various types of facilities have been developed and about 90 of them completed on 1959-60 operations. Most of the information from them had not been tabulated and analyzed as of June 1960.

The most important observations based on the work to date are:

1. The difference in loss of value per barrel of rough rice during drying and storing is not statistically significant between farm facilities and commercial facilities.
2. Wide variation in drying and storage results indicate that facility owners (commercial and farm) can decrease their loss per barrel.
3. During the past 5 years, the average yearly rise in mid-monthly prices received by Louisiana farmers has been 26 cents a barrel, as compared with $1.51 during the previous 5-year period. This serious drop in prices, along with the decrease in rice acreage, seems to have discouraged farmers in the purchase of farm drying and storage equipment.

These observations are based on a small sample. When additional data have been obtained they may be modified.

Factors Affecting the Cost of Operation of Rice Mills in the South

Nicholas M. Thuroczy*

As an approach to increasing marketing efficiency for rice, the U. S. Department of Agriculture has recently conducted a study of operating costs in the rice milling industry. The major objective of this study was to provide a guide to the individual rice miller to evaluate his operating efficiency and his own competitive position within the industry. Rice mills, handling approxmately 75 percent of the entire Southern rice crop, participated in this study.

Cost accounting data were used in this study. Since the main function of the rice mill is to convert the rough rice into a milled form, the unit cost—based on cost accounting data for each mill—was expressed in terms of the annual volume of rice milled.

The annual volume of rice milled was different among plants. Some mills restricted their operations to milling only; others dried or packaged, or performed both operations in different proportions of their annual rice milled.

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Most mills indicated some variations in their annual milling capacity utilized. Differences also were apparent in management practices. As a result of the wide variety of services which these mills rendered, unit costs also were expected to show a considerable variation.

To determine why and to what extent unit costs were different in various rice mills, the effect of five major factors on costs were investigated: (1) the annual volume of rice milled; (2) packaging operations; (3) drying operations; (4) the milling capacity utilized; and (5) management practices. Storage operations in this study were considered as part of the standard milling operations and handling. Parboiling operations were not analyzed.

Because of insufficient data on management practices, this aspect could not be treated fully in our study. Only milling and packaging operations could explain the differences in unit costs among the mills.

The study showed that a mill restricting its operation to milling only, and handling an annual volume of 1 million hundredweight of rough rice, would be expected to incur a unit cost of milling, including administrative and selling expenses, of about 70 cents per 100 pounds of rough rice milled. Mills operating at smaller annual volume would be expected to have a higher per unit cost. On the other hand, mills would be expected to have only slightly lower unit costs, if they operated at a volume larger than 1 million hundredweight annually.

On the basis of this finding, it appears that, on the average, the most efficient milling plants in the industry are those which operate in excess of 1 million hundredweight of rough rice annually. This, of course, is true for the average mill; it may not be true for all mills in this volume category. Undoubtedly there are mills in the industry with a much smaller annual volume which operate just as efficiently as mills in the large volume category.

Our study established six major cost categories for milling operations. Approximately 40 percent of the total cost represents payments to labor and other personnel.

As expected, packaging operations had a strong influence on total unit cost among mills. Since packaging (in 5-pound or smaller containers) usually is considered as a sideline operation to milling, we used a measure of percentage of the milled rice packaged as a separate factor in determining the impact of this operation on total unit cost.

As the percentage of the rice packaged increases, that is, as packaging operations become more and more important in relation to milling operations, the total unit cost also will increase. However, these successive additions of costs to the total will become smaller and smaller with equal percentage increase in packaging operations indicating the inherent advantages, up to a point, of a large scale packaging operation in relation to milling. After reaching a level of about 35 percent, there will be little change in additional unit cost when packaging operations are further increased.

I would like to add a few words on our program of research. The question often comes up, how does such a study as this fit in with the Department's research to increase the efficiency of marketing of agricultural products? As you know, Congress in 1946 passed the Agricultural Marketing Act, which among other things, requested the U. S. Department of Agriculture to carry on research in the field of marketing, with the objective of providing information on how the spread between the farmer and the consumer could be reduced. There are many commodities for which these studies are conducted in the Department and these studies are revised continually to bring data up to date. The rice milling industry usually represents a significant, although not the major cost segment, in the marketing of rice. A more efficient milling industry would mean lower marketing costs for rice and possibly an increase in consumption of rice, at least in certain areas of the United States. It also may increase exports. Since the rice milling industry is basically competitive, any savings are likely to be passed on to the farmer or to the consumer.

Education and Extension Section

R. J. Hodges, Jr., Moderator

How Farm People Adopt New Ideas

Lewis Hill*

How to reach farm people more quickly and effectively is receiving more attention every year. A great deal of research already has been done along these lines and more is in progress. In Louisiana, particular emphasis has been placed on finding out how far along farm people are in relation to their adoption of recommended practices. An attempt is being made to pin-point what practices seem to need most attention. Louisiana extension personnel are increasing their use of findings about how farm people adopt new ideas.

The process through which people go, from the point of awareness of a new practice to the adoption of that practice, has been divided into five stages: awareness, interest, evaluation, trial and adoption. Defintely distinguishable processes usually take place during each stage, however, these stages may overlap and may vary considerably in time.

Distinct patterns of sources of information can be observed. Of considerable importance to action agencies is the finding that the effectiveness of various methods of communication differ according to the various stages of the adoption process. For example, various types of mass media have been most effective in the awareness stage. Contacts with friends or neighbors have been more effective in the trial stage.

Farm people have been classified into different categories according to their rate of adoption (or non-adoption) of practices. They are: inovators, early adopters, early majority, majority and non-adopters. Those who adopt new ideas first are the "inovators." The group which offers the greatest challenge is the "majority." This group make up over 60 percent of the farmers and they are the last to adopt new practices.

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Potentials of Long-grain, Short-season Rice Varieties

R. J. Hodges and N. S. Evatt*

Rice selections that can mature in approximately 100 days soon will be available to farmers in the southern rice area. Research indicates that these short-season, long-grain varieties have desirable agronomic and processing characteristics as good or better than existing varieties. Such short-season varieties offer farmers several advantages: lower production costs, possibility of other crops, or a second rice crop being grown on the same field, more efficient use of water and reduced weather hazards.

In Texas, an estimated 10,000 to 20,000 acres of the commonly-grown, early-maturing varieties were used for double cropping during 1959. Government acreage restrictions obviously favor such a practice and these "100-day" varieties should be valuable to farmers who contemplate stubble production. Increased production from two crops, but from only one planting, lowers the overall cost of the rice produced because of the relatively low production cost of the second crop.

When these high-quality, long-grain, short-season varieties with their stubble crop potential are put into production, farmers can realize more profit per acre than they are now making from early-maturing, medium-grain varieties. Any great increase in medium-grain rice at the expense of long-grain rice would not be a healthy situation for the southern rice industry because many of our domestic and foreign markets are based on long-grain rices.

These long-grain, short-season varieties should be popular with rice farmers. However, there will be an acute need for expanded educational efforts by the Texas Agricultural Extension Service to acquaint farmers with their agronomic characteristics and necessary changes in management practices if the full benefits of these newer varieties are to be realized. Practices such as proper seeding dates, fertilization, irrigation and weed control will be intensified greatly with the advent of the short-season varieties. These varieties mature within 100 days under ideal conditions.

The need for an educational program to help farmers realize maximum yields from varieties that differ from those commonly grown was experienced in 1959 when farmers began to produce stubble crop rice on a large scale with early-maturing varieties. Recent research regarding production of stubble rice is important information that a farmer must use to get maximum returns from early-maturing varieties. Four years of research, which began in 1956, indicate that yields approaching 40 barrels per acre are possible from a combined first and second crop of Century Patna 231. Gulfrose, which matures 10 to 16 days earlier than Century Patna 231, produced stubble yields of 2,000 pounds per acre at the Beaumont Station.

In 1959, the station had a stubble test on one of the promising "100-day" selections. It was not seeded until May 1; yet sufficient time was available for a second crop. Sixty days after the first harvest, 1,900 pounds of rough rice per acre were produced from these plots which had received 120 pounds of nitrogen per acre to the stubble. The total yield of both crops was over 5,700 pounds.

This research indicates that 25 to 50 percent of the original crop can be produced from a stubble crop using short-season or early-season varieties, provided additional nitrogen is applied immediately after harvest. Three-fourths of the original nitrogen rate should be applied to the stubble for the most economic returns. In the tests, the normal combine cutting height, which left a 17 to 18-inch stubble, was satisfactory. Highest yields were obtained when the plots were flushed following the nitrogen application and kept moist, but not flooded, until new tillers were 4 to 6 inches in height. The original crop should be harvested by the middle of August.

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REGISTRY OF ATTENDANCE

Rich Technical Working Group

Lafayette, Louisiana, June 29, 30 and July 1, 1960

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