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Résumé. *Les riziculteurs californiens, en collaboration avec les chercheurs, ont mis en œuvre un programme efficace de recherche et de vulgarisation financé à la fois par des fonds publics et une participation des producteurs eux-mêmes. La formation d'un bureau de recherche pour le riz, sous la direction des producteurs et avec leur contribution directe au financement, a certainement joué un rôle important dans l'évolution rapide des résultats obtenus. Cette recherche répond aux besoins de la production californienne par le développement des variétés, la lutte contre les maladies, la fertilisation et la gestion de l'environnement.*

Abstract. California rice growers and scientists have collaborated in an aggressive research and grower education agenda driven by both private and public funding. The formation of the grower-directed Rice Research Board, and a self-assessment to collect funds to support research greatly accelerated advances in production. This research has addressed critical needs for the California rice industry in variety development, pest management, nutrition, and the environmental sciences.

I – Brief history and introduction to rice research in California

In the early 1900s the United States Department of Agriculture (USDA), University of California (UC) and growers were successful in establishing commercial rice production in California. Experimental attempts to grow rice before the turn of the twentieth century failed largely because of poorly adapted cultivars and the selection of geographic areas too cold for rice production. To ensure the success of a new rice industry in California, the USDA and the Sacramento Valley Grain Association entered into an agreement to establish a research station for cereals in the Sacramento Valley, California. This agreement led in 1952 to the formal organization of the present day California Cooperative Rice Research Foundation, Inc. (CCRRF) that owns and operates the Rice Experiment Station (RES). Both USDA and UC Scientists collaborated in early on- and off-station research. In 1953, UC Department of Agronomy became more directly involved in the shared costs and voluntary contributions from the rice industry. In 1969, a grower referendum under the auspices of the California Marketing Act established a mechanism for the collection of funds from all rice growers for the purpose of accelerating rice research programs. Funds from the California Rice Research Marketing Order administered by the California Rice Research Board (RRB), public funds for research from the USDA and UC, CCRRF funds and smaller proprietary rice research programs form the financial underpinning of the current organization for rice research in California.

II – Rice production in California

California rice is produced as a single crop per year on approximately 200,000 ha in a Mediterranean climate. The crop is entirely irrigated, largely from gravity flow systems out of reservoir storage derived from Sierra Nevada Mountain rainfall and snowmelt (> 75%) or from well water (<25%). The relative amount of each source of water varies annually with the availability of surface water. The soils are mostly impermeable fine textured clays or clay loams underlain with hardpans. The cultivars are largely japonica medium and short grain types with very little cultivation of long grain. Small acreages mochi and aromatic types are grown for specialty markets. In California, rice is almost entirely aerially seeded into flooded fields after pregerminating the seed in water for 24-48 hr. Relatively small acreages are drill- or dry-see-

ded. Nitrogen fertilizer is applied preplant incorporated and topdressed if needed—as determined by leaf tissue analysis. Phosphorous is also generally applied at 30-40 kg ha^{-1} and incorporated. Potassium, zinc and very few other nutrients are applied based on soil analysis. Weeds, insects and diseases are all important pests in California rice production. Weeds are the principal concern because of their devastating competition with rice and the great number and diversity of grass, broadleaf and sedge weeds in the rice cropping system. Insects and invertebrate pests are less widespread, but can be devastating where they occur in great numbers. Stemrot and aggregate sheath spot are quite widespread, but are more subtle in their impact on yield. Relatively few pesticides are applied to California rice, but environmental issues related to the use of pesticides and their impact on water quality heavily regulate irrigation management. Rice is harvested in September and October and California rice yields are among the highest in the world with statewide average yields above 9 t ha^{-1}. The postharvest management of rice straw, historically burned, has also been recently regulated and is increasingly disposed by soil incorporation. Winter flooding of rice fields to enhance straw decomposition and provide waterfowl habitat has greatly improved the public perception of California rice farmers.

III – Current organization of rice research in California

The Land-Grant University system of the United States was enacted by federal legislation in the 1800s and modified over the years to establish Agricultural Experiment Stations and Cooperative Extension education so that research and diffusion of information would occur together. The impact of this legislation on the efficiency of US farming can not be understated. Unlike many agricultural research organizations in many countries, the US innovative advances from research were coupled with extension outreach and a rapid adoption of new practices by agricultural producers and their allied industries.

Currently in California, rice research is conducted primarily by three entities, the grower-funded RES, the USDA-Agricultural Research Service (ARS) and UC. Proprietary rice organizations conduct additional research, primarily focused on cultivar improvement. Furthermore, national and international agricultural companies conduct proprietary research, most often for crop protection, with a component of their effort in rice. This paper will address primarily publicly funded programs.

1. The California Rice Research Board

Rice research in California is dependent on a mix of public and rice grower funds. In contrast, similar research in the southern USA states where rice is produced is financed by considerably higher levels of public funding. The approval of the Rice Marketing Order referendum in 1969 and its subsequent reapproval at five year intervals provided the funding for an aggressive research program in California. The marketing order allows for mandatory assessments of up to $0.05 per 40 kg rice and generates $1.5 to $2.0 million annually. The allocation of funding is determined by the California RRB, a body of rice growers elected by district in proportion to their district's production. The State of California designates UC as the lead agency for marketing order research. Through collaborative agreement, the RRB awards research funding competitively, primarily to the RES and UC for a wide variety of research programs (Figure 1). Other research projects are occasionally funded depending on the availability of funds and the priorities of rice growers. In California, the RES is the primary beneficiary of RRB funds in support of an extensive variety development program, receiving about $1.1 million annually. The University of California receives approximately $0.5 million annually for a variety of research projects.

2. The Rice Experiment Station

The RES was founded in 1912 as noted in the introduction. Following the approval of the California Rice Marketing Order in 1969, the RES established a charter to operate as a non-profit research foundation owned by California rice growers and under the guidance of a grower-elected board of directors. Although more limited in its mission, the RES policies reflect those of public institutions. A Memorandum of Understanding designated research areas and collaborative relationships between the RES, the USDA and UC. The RES's primary mission is to accelerate the development of improved varieties, the USDA to provide genetic innovations and germplasm enhancement as well as food product development, and UC to conduct research on rice culture; including agronomy, pest management, engineering,

economics and other areas. The RES is also responsible for the production of Foundation seed as the starting point of an extensive certified rice seed program in cooperation with the California Crop Improvement Association. The RES scientific staff includes the Director of the Station, Dr. D. Marlin Brandon, three plant breeders, one pathologist and several professional staff. The facility consists of 150 ha of field, greenhouse and laboratories as well as equipment used for research and seed production. Additional funding for the RES is derived from Foundation seed sales and from the Rice Research Trust, a tax exempt trust for voluntary contributions from growers and other entities in support of rice research.

3. The United States Department of Agriculture

The USDA-ARS provides fundamental research as a federal program to improve agriculture. Although the scope of USDA research programs extend beyond state and crop boundaries, two USDA programs contribute directly to the benefit of the state's rice growers. A USDA-funded rice geneticist, Dr. David Mackill, is housed in the Department of Agronomy and Range Science at UC Davis as a collaborative partner with other cereal genetic programs. The USDA genetics program introduces new germplasm and breeding strategies for California rice cultivar improvement working closely with the RES breeding program. The Western Regional Research Center in Albany, CA, conducts general research on food product development including the stabilization of rice bran, rice flour products, extrusion technologies and other studies on rice mill products. In addition to USDA rice programs in California, collaboration with USDA scientists from the other US rice states is common.

4. The University of California

UC Experiment Station scientists conduct a wide range of research projects. Although appointed primarily to work in scientific disciplines related to agriculture, many UC scientists choose rice as the primary crop for their scientific studies. Clearly, the opportunity for funding from the RRB through competitive proposals exerts a strong influence on encouraging these scientists to work on rice. In addition to RRB funding, UC scientists attract substantial additional funding for rice research through the Rockefeller National Science Foundation (NSF), the USDA Competitive Grants Program and many other federal, state and private granting agencies and donor groups.

UC scientists are located in departments related to their discipline thus enhancing the opportunity for interaction with colleagues in the same discipline, but working on agricultural systems other than rice. Cross disciplinary collaboration is facilitated by a UC Rice Workgroup and ad hoc subgroups that meet to establish priorities and protocols for research. Workgroup membership includes both statewide and county extension personnel as well as RES scientists to ensure collaboration in both research and grower education programs. Contributing UC departments are Agronomy and Range Science, Agricultural and Resource Economics, Agricultural and Biological Engineering, Entomology, Environmental Toxicology, Food Science, Land Air and Water Resources, Plant Pathology and the Weed Science Group. Three local rice advisors (Farm Advisors) and one campus-based rice specialist contribute applied research and extension education programs in nine rice growing counties (areas) with two additional advisors making part-time contributions in smaller rice growing areas. The extension group collaborates closely with the RES rice breeders in an extensive statewide field testing of rice experimental cultivars in support of new variety releases.

Summary. *Rice research programs in California are conducted by public (USDA and UC) and non-profit grower managed (RES) organizations as well as a few proprietary entities. Research funding is provided by state and federal support in salaries and grants to public scientists, grower check-off funds under the California Rice Research Marketing Order and private contributions. California rice growers interact in setting priorities and the direction of this research through input to their elected members via the Rice Research Board and the Rice Experiment Station Board. Furthermore, politically active grower organizations such as the California Rice Promotion Board and the California Rice Industry Association as well as the RRB and RES Boards are active in securing additional financial support for high priority rice programs. Specific research projects among collaborating scientists are coordinated through UC Rice Workgroup activities in which all public rice scientists participate. The program has been highly successful in solving grower problems through improved varieties, pest control and management, soil and crop nutrition as well as contributing to the solution of environmental concerns.*

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Figure 1. Organization of projects by the California Rice Research Board