RF Bd. OF TRUSTEES 4/93 RF 93001

Basic and Applied Rice Biotechnology

RF 93001

GUIDELINE: Applying Biotechnology to Developing-Country Food Crops

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GRANTEE: For allocation by the officers

OBJECTIVE: To support research and training at industrialized-country laboratories participating in the Foundation's international program on rice biotechnology.

AMOUNT: $2,400,000 in addition to RF 92001

DURATION: Period ending March 31, 1994

STRATEGY: The Foundation's rice biotechnology program, launched in 1984, has two goals: providing improved varieties that will enable production in rice-dependent countries to keep pace with population growth, and building up those countries' scientific capacity as an essential ingredient for economic development. To accomplish these goals, an international network that now comprises roughly 200 senior scientists and 300 trainee scientists has been established to develop and apply powerful new tools of genetic engineering to the genetic improvement of rice. The network combines the skills of many of the world's leading plant molecular biologists with those of scientists responsible for rice improvement in developing countries. The industrialized-country laboratories in the network undertake basic and applied research on the program's more complex high-priority research objectives, provide training for third-world scientists, and through a chain of research collaborations transfer new knowledge and materials to rice improvement programs in developing countries. Scientific progress has been excellent, the first of the trainees are returning home to establish their own research programs - often in partnership with the laboratory where they received training - and the work at the industrial-country institutes is becoming more sharply targeted.

DESCRIPTION: The status of the work at the developed-country laboratories (list attached) can be summarized as follows.

1. *Genetic maps and markers.* The research on development of genetic maps and markers and their application in rice breeding is one of the strong points of the program. The rice map now has over 600 markers, a number more than adequate to tag and follow the inheritance of important genes. Molecular maps of the most important fungal and bacterial pathogens of rice are now also available. Using the rice and pathogen maps together enables rice breeders to make more effective use of classical genes for resistance and to breed for resistance that is durable and long lasting. (Workshops for transferring this mapping technology to developing countries are funded separately.) Current needs are research focused on making this technology less expensive and more usable under field conditions in developing countries and improved coordination of the various gene-tagging experiments. Further development of the map as a tool for gene cloning is a longer-term goal.

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2. *Techniques for foreign-gene transfer.* Development of techniques for the transfer of foreign genes into the rice genome, i.e., transformation, was one of the early and most significant accomplishments of the program. This was a first for any cereal, and the field testing of transgenic rice plants during 1990 marked another first. Since refinement of these techniques into routine procedures is still some distance away, three laboratories in the U.S. and two in Europe are supported in part to provide rice genetic transformation services for others in the program. During the past year they have produced transgenic rice plants that contain one or more of nearly two dozen potentially useful gene constructs generated by numerous laboratories in the program, and these are now being evaluated. Research groups outside the program have expressed interest in utilizing this rice transformation capacity and in turn making their genes available for use in rice.

3. *Mechanism of gene regulation in rice.* Many of the more sophisticated and powerful uses of rice genetic engineering will involve turning genes on or off in particular cells, tissues, and/or organs at particular stages of plant development and/or in response to particular environmental stimuli. For example, regulation of tissue- and temporal-specific expression of genes for inhibitors of insect pests would enhance and prolong the genes' effectiveness. Research aimed at understanding and using these control processes is proceeding well. Continuing support, at about the same level, will now be targeted to specific needs.

4. *Useful traits.* Most of the advanced laboratories added to the program over the past few years are concentrating on the identification and cloning of genes that can instill useful traits assigned high priority. Priorities were established by a comprehensive, quantitative analysis that incorporated estimates of the production, equity, and environmental effects of each, as well as the likely feasibility of successfully finding and introducing a gene for each. Now under test are candidate genes for virus resistance, insect resistance, improved nutritional quality, and male sterility. Engineering more complex traits - such as drought tolerance - which are controlled by many genes, will be a long-term process, but promising strategies are being pursued.

In February 1993 the sixth "annual" meeting of the program was held in Chiang Mai, Thailand. Over 300 scientists participated, presented and discussed their results, and further developed collaborative research, training, and technology transfer efforts.

RISKS/EVALUATION: Numerous field tests of genetically engineered crops have now been conducted, none of them occasioning any biosafety surprises and almost all demonstrating the effectiveness of the new traits derived from "alien" genes - genes taken from other species. The officers therefore no longer see a risk that alien genes will not work in rice or that they will pose a biosafety threat. The present high cost of rice transformation, however, continues to hamper transfer efforts. Although in all network activities the officers stress the principles of ecology and population biology which can enhance and prolong the usefulness of the new traits, there remains a risk that those designing and using ge-

netically engineered rice plants will not give the principles adequate attention.

A major evaluation of the overall program is currently under way, headed by David Bell, former administrator of the U.S. Agency for International Development and former vice president, of the Ford Foundation's International Division. The findings and recommendations concerning future directions for the program are scheduled to be discussed with the Board later this year or early in 1994.

BUDGET: The appropriation would be used as follows to renew support for several laboratories currently part of the program and to support a few new research projects:

Scripps Research Institute	$ 350,000
Texas A&M University	250,000
John Innes Institute, England	300,000
Washington State University	300,000
Commonwealth Scientific, Industrial, and Research Organization, Australia	250,000
University of Durham, England.	200,000
Cornell University	200,000
Purdue University	150,000
University of Wisconsin	150,000
Texas Tech University	150,000
Jacques Monod Institute, France	100,000
Total	$2,400,000

FURTHER SUPPORT: The officers expect to recommend further support for the rice biotechnology program at roughly the present level.

Developed-Country Laboratories Participating in the Foundation's International Program on Rice Biotechnology

University of California at Berkeley	Barbara Baker	Site-directed gene transfer
Commonwealth Scientific, Industrial, and Research Organization, Australia	Wayne Gerlach	Resistance to ragged stunt virus
	Merv Ludlow	Drought tolerance
Cornell University	Steve Tanksley	Genetic maps and markers
	Ray Wu	Genetic transformation/insect resistance
University of Durham, England	Don Boulter	Insect resistance
University of Georgia	Gary Kochert	Genetic markers
	Sue Wessler	Transposable elements
Jacques Monod Institute, France	Anne-Lise Haenni	Resistance to hoja blanca virus
John Innes Institute, England	Roger Hull	Resistance to tungro virus
Kansas State University	Jan Leach	Bacterial-blight resistance
	S. Muthukrishnan	Sheath-blight resistance
University of Kyoto, Japan	Kunisuke Tanaka	Improved quality of rice storage protein
Michigan State University	Mark Whalon	Insect resistance
University of Missouri	Roy Morris	Yield enhancement
University of Montreal, Canada	Andrew Hanson	Drought tolerance
National Institute of Agronomic Research, France	David Tepfer	Drought tolerance
University of Nottingham, England	E. C. Cocking	Protoplast techniques
University of Ottawa, Canada	Illimar Altosaar	Tissue-specific gene expression for insect resistance
University of Pennsylvania	Joe Ecker	Genetic mapping
Purdue University	Thomas Hodges	Genetic transformation/insect resistance
	John Hamer	Blast resistance
	Ray Bressan	Drought tolerance
Rockefeller University	Nam-Hai Chua	Gene regulation/drought tolerance
Salk Institute	Chris Lamb	Defense genes
Scripps Research Institute	Roger Beachy	Resistance to tungro and yellow mottle viruses
Stanford University	Virginia Walbot	Mitochondria genes/cold tolerance
Swiss Federal Institute of Technology, Zurich	Ingo Potrykus	Genetic transformation/carotenoid synthesis
Texas A&M University	Tim Hall	Rice transformation service
Texas Tech University	Henry Nguyen	Drought tolerance
University of Tokyo, Japan	H. Uchimiya	Defense genes
University of Washington	Eugene Nester	*Agrobacterium*-mediated transformation of rice
Washington State University	Gyn An	Hybrid rice
	Tom Okita	Storage proteins/starch synthesis
	Hei Leung	Blast resistance
University of Wisconsin	Sally Leong	Blast resistance
Virginia Tech University	M. A. S. Maroof	Hybrid rice
Ohio State University	D. P. S. Verma	Salt tolerance/nitrogen uptake
Rutgers University	Ilya Raskin	Defense genes
University of Fribourg, Switzerland	J. P. Metraux	Defense genes