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The Agriculture Grants Program

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Summary. The Competitive Research Grants Office was established in 1978 by the federal government to encourage and support basic research related to agriculture. The effort has been enfeebled by controversy and continues to teeter on the edge of congressional extinction. The origins of the Competitive Research Grants Office and its first 3 years of operation make an interesting portrait of the problems of science and government in these times.

The Competitive Research Grants Office (CRGO) was established in 1978 to implement a section of the Food and Agriculture Act of 1977 (*1*). Its purpose is to make grants to support basic research in areas of science that underlie agricultural productivity and human nutrition. The origins of the office are numerous, and its creation by Congress was the result of a convergence of many forces.

Researchers interested in basic aspects of plant biology have often felt like "poor relations" in the scientific community. Support for such research has come from the National Science Foundation (NSF), the National Institutes of Health (NIH), the Department of Energy (DOE), and the Department of Agriculture (USDA). The USDA support has been directed largely at the more applied aspects of plant science and has been confined mainly to scientists in the state Agricultural Experiment Stations and the federal laboratories operated by the USDA. A substantial number of scientists outside the traditional agriculture community received support from the NIH to do research on fundamental aspects of photosynthesis, nitrogen fixation, and other processes which occur in plants, but which are fundamental to the understanding of life and may contribute to understanding processes directly affecting human health. In 1968 a refinement of NIH mission goals led to withdrawal of grant support for most of these projects in plant science. Although the NSF and DOE maintained and even increased their support of plant science research, practitioners in this area felt that their potential for accomplishing important science was sadly limited, especially by comparison to the generous support from the NIH for work on animal and bacterial processes. There was a sense that great scientific opportunities were within reach as a result of breakthroughs in other areas of biological research.

A more powerful impetus to foster plant science research was to come from the world at large. In the 1970's world grain reserves were drawn down, and world population continued to grow at a frightening rate. Sunday newspapers often described the grim realities of starvation in the Third World and the grimmer prospects of famines to come. At the same time, U.S. food exports were soaring and were identified as a major economic success in world markets. The U.S. grain surpluses were reduced, and it seemed time to focus on ways to improve agricultural productivity and help balance oil imports with food exports.

Finally, it was realized that agricultural productivity, which had grown mightily during the postwar decades, might be leveling off. The great gains in productivity achieved during the Green Revolution had come from traditional techniques of plant breeding, from high energy inputs in the mechanization of farm practices, and from high chemical inputs in the use of fertilizers, pesticides, and plant growth regulators. There was concern that too little new knowledge was being generated which could provide for future gains. The economic and environmental costs of the energy and chemical inputs were rising astronomically. New, fundamental knowledge about plants seemed to be needed to help solve these practical problems.

In the middle 1970's, a conference at Boyne Highlands, Michigan, sponsored by the Michigan State University Agricultural Experiment Station and the Charles F. Kettering Foundation, signaled that some important steps had been taken (*2*). The combination of sponsors of this conference showed a new alliance of a traditional USDA- and

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state-supported agricultural research laboratory with a private institution engaged in basic research. This was reflected in the participants at the meeting, who worked at Agricultural Experiment Stations, land grant universities, public or private universities in both urban and rural settings, USDA federal laboratories, and private research institutes. At this meeting, at Gordon Conferences, and at professional society meetings in this period, there was increased communication between scientists who worked close to agricultural applications and those who worked on basic plant problems. One purpose of the Boyne Highlands meeting was to have the practitioners of plant science identify areas of research with the greatest potential for improving crop productivity. Some of the recommendations of the conference survived in recognizable form in the legislation that established the CRGO. It is an unfortunately rare but certainly a happy day when a broadly representative group of research practitioners can identify priorities for research emphasis and see these priorities implemented in a new grants program.

It would be wrong to leave the impression that the Boyne Highlands meeting was the only one of its kind, or even the most influential effort in creating this grants program. There were many efforts by the plant science research community, by various national study groups and societies, by science administrators within the federal government, and by the congressional Office of Technology Assessment. Establishment of a research grants office in the USDA was recommended by several National Academy of Sciences studies (*3–5*).

Representative Ray Thornton began work on a congressional response, and in 1976 Representative William C. Wampler introduced a bill (HR 11743) to establish a basic research grants program in the USDA; this was enacted in 1977 and funds were available in 1978.

Procedures and Operations

The CRGO was created to increase the basic research effort which must underlie advances in agricultural technology. The office was expected to play a role complementary to the efforts of the research programs of the USDA, which include both the in-house federal research laboratories known collectively as Science and Education Administration/Agriculture Research (SEA/AR) and the research done by cooperators of the USDA in the State Agricultural Experiment Stations, which is administered by Science and Education Administration/Cooperative Research (SEA/CR). However, some of the participants in these established branches of SEA viewed the new organization as being formed at their expense. In the late 1970's, the Agriculture Research branch suffered reductions in personnel ceilings. The Cooperative Research branch, whose funds when distributed to the Agricultural Experiment Stations are often used to pay salaries of researchers, had not received budget increases to keep pace with inflation. It was possible to assume that the new activity was being created at the expense of salaries of loyal employees.

The policies that were to govern the new grants program were, in part, set by the congressional mandate. Grants were to be made to support basic research in four areas of plant science: nitrogen fixation, photosynthesis, biological stress on plants, and genetic mechanisms for improvement of crops. These areas were selected on the basis of the priorities set by researchers at the Boyne Highlands meeting and other such gatherings. One area of research that had been mentioned with these four at many early meetings dealt with physical stress on plants, but this area was dropped from the congressional list. There has been a strong feeling in the research community that more work is needed on the effects of stress related to such factors as water, minerals, and temperature (*6*), and efforts to establish such a program continue. An additional program was mandated by Congress in human nutrition. Congress further specified that the grants were to be based on peer review and open to applicants from the broadest possible spectrum of institutions. Some of the traditional clients of the USDA had profound misgivings about this. A peer review panel operating at the national level was viewed as Washington intruding in local affairs, since other USDA funds come to Agricultural Experiment Stations and are assigned to projects within the stations at the local level. Further, awarding grant funds to researchers at institutions outside the traditional network of experiment stations, land grant colleges, and federal research laboratories seemed to be diverting a sorely limited budget from established agricultural projects to outsiders.

The operational policies for conducting the peer review process and awarding the grants were adopted from the vast experience of the NSF and the NIH. Policies were regularly put before a policy advisory group of scientists, university administrators, and granting agency officials, who tested them for suitability to the researcher's needs, the needs of the institution at which the research would be conducted, and the requirements of government granting practices. In addition, this group was asked to review the details and accomplishments of each program prior to and at the end of the granting cycle. Each program area is administered by a program manager and an associate program manager. To ensure scientific stature and a regular infusion of new viewpoints, the program manager positions were to be occupied by active research scientists on leave from their institutions. To provide program continuity and experienced support, the associate program managers were to be career government employees with professional training in the subject areas.

An operational cycle of proposal review and awarding of grants has evolved in the 3 years of CRGO activity. When the congressional appropriation of funds becomes law, a notice published in the *Federal Register* officially informs the applicant community of the competition and the deadline for receipt of proposals. The congressional decision to continue the program came at the end of the government fiscal year in 1978 and 1979. In 1980 final congressional action was delayed until after the presidential election. Potential applicants need not wait for the appearance of the *Federal Register* notice. Assuming favorable congressional action, proposals prepared and submitted before the deadline will be received, acknowledged, and kept by the Competitive Research Grants Office for evaluation.

After the deadline for submission, all proposals are reviewed by a program manager, and a peer panel is recruited whose members, by virtue of their research expertise, are best suited to evaluate that group of proposals. The panelists take several months to read the proposals, and during that time ad hoc reviewers knowledgeable in the subject matter are asked to read the proposals and mail in reviews. In the spring the panels are convened, all the reviews are considered in the context of all the proposals submitted to a given program, and a series of priority judgments are worked out by consensus of the panel. These recommendations are then translated into grant award recommendations based on the available funds. It is the policy of the CRGO to help declined applicants understand the reasons for failure to win funds and to suggest areas for improvement of future proposals. Therefore a summary of the panel's per-

ception of the scientific quality of an application is prepared and sent, on request, to the applicant. However, given the large demand for scarce funds, some projects fall below the cutoff line, not for a specific technical fault or misplaced emphasis that can be corrected, but because the panel finds them less likely to yield important results. All the applicants are informed of the decisions during the summer, and the several exchanges of correspondence necessary to activate a grant must be completed by the end of the fiscal year on 30 September.

The time required for this process is certainly long. The applicants must be given time to prepare proposals, the reviewers time to evaluate them, and the administrators time to comply with the many mechanisms and rules of accountability. In the early 1960's a research grant application could be funded 4 months after its receipt in Washington, while now most agencies have an average response time of nearly 1 year. If the CRGO could establish itself on a more permanent basis, the anxiety about deadline dates and program continuity would diminish.

Congressional Appropriations

Congress was much less supportive of the grants program when it acted on the 1978 budget than when it wrote the Food and Agriculture Act of 1977. The 1978 Executive Budget requested $27.6 million for a grants program to support basic research in four areas of plant science identified by the research community. Congress finally appropriated $15 million, $5 million of which was designated for human nutrition research. The original authorization in the Food and Agriculture Act had called for a $25-million budget for plant sciences in the first year and $5-million increments in each subsequent year of a 5-year period. The 1979 Executive Budget requested $30 million for support of the CRGO programs that coincided with the 1977 congressional authorization. Congress appropriated $15 million for 1979. The 1980 Executive Budget requested $30 million. The House Agriculture Appropriations Committee recommended, as it had in the previous year, zero funding, but the Senate endorsed the President's request. A compromise brought $16 million to the competitive research grants, which seemed at least a symbol of progress; unfortunately, half of the modest $1-million increase was lost in a summer rescission. The 1981 Executive Budget requested $25 million for the CRGO programs, and the hope was expressed that this moderate approach would win over the House Agriculture Committee and result in an appropriation at or near the requested level. The House responded by recommending zero funding again, and the Senate delayed action until after the election. The joint committee of the Senate and House compromised at $16 million, and hopes for the funding levels detailed in the 1977 congressional authorization have faded.

The recitation of numbers in the paragraph above glosses over many interesting details of the congressional appropriations. In view of the complexities of modern bureaucracy, it was remarkable that the 1978 appropriation was spent at all. The CRGO had the barest of skeleton crews. The scientific evaluations and technical requirements for making grants were mastered, however, and the appropriated funds were used as intended by Congress. In this first year of activity, the next drama of appropriations began. The USDA's proposed budget for the following year showed an increase for competitive research grants from $15 million to $30 million and, on an adjacent page, a reduction of $15 million in the Hatch and McIntire Stennis funds. These funds are distributed by formula to State Agricultural Experiment Stations and schools of forestry with a long record of socially beneficial results, and they are vigorously defended by a large constituency. The fight for appropriations was at times bitter, and the resulting congressional compromise restored the formula funds and left the CRGO with no growth and many wary antagonists. This was an example of the difficulties faced by new programs set into departments of government with a well-established and politically active constituencies. Because the traditional programs are large, they require large increases to keep up with inflation. It becomes very difficult to achieve growth in a new program when the needs of the other programs are not satisfied. This was the lesson of 1979.

The discussions of the 1980 budget raised other issues. Were any results being achieved with these grants? The projects are long-term ones addressed to fundamental processes, but could one see any progress? Was the peer panel mechanism a "buddy system" in which scientists passed off taxpayers' dollars to their friends? Apparently the congressional critics were either unaware of or unconvinced by the National Academy of Sciences study which found the peer panel process to be a fair and effective way to identify the best research opportunities (*7*). Finally, with the appropriation came a Golden Fleece Award to part of the human nutrition program, and more detailed congressional control of the appropriation to the CRGO.

When the human nutrition program was instituted by Congress, both the nutrition research community and the USDA explicitly endorsed the idea of funding research in the social and behavioral aspects of human nutrition. While the main thrust of the program was to be support of laboratory research on mineral and vitamin requirements, interaction of dietary constituents, and so on, a project to study the basis of vegetarian food choice had received grant support. In fact, the project had a large laboratory science aspect, since the scientists were examining the biochemical machinery associated with taste of foods and its modifications among vegetarians. Apparently, however, the study of vegetarian behavior is an inflammatory business. The Golden Fleece Award to the project suggested that such a study must be trivial, and it somehow prompted a number of lobbyists for meat-producing groups to assume that the CRGO was endorsing vegetarianism. Congress specified that no more funds would be spent on research on the social and behavioral aspects of human nutrition. Further, the human nutrition program was reduced not simply by the $1 million previously spent on social and behavioral studies; an additional $1 million was shifted into the plant science programs. The 1980 appropriation also contained specific instructions on how the funds should be distributed to the programs. This distribution of funds was related to previous granting activity, but prevented shifting of funds from one program area to another, even if called for by a shift in the quantity and quality of proposals received.

Relations with the Applicant Community

Table 1 shows the number of requests from and awards to applicants. Several observations can be made from these statistics, although valid conclusions about trends cannot be drawn without more years of experience. There is evidence that the grants program attracted many applicants. It is clear that there is a potential for more research in the plant sciences and human nutrition. We attribute the decline in the number of proposals submitted each year to the very small number of successful applicants and the greatly reduced grant budgets received

by successful applicants; the competition has high odds and small rewards. The scientists on the CRGO staff and the peer panelists consider that the overall quality of the submitted proposals has been high. In each of the 3 years of competition, more than 50 percent of the proposals received were judged by the peer panels to be worthy of funding.

Other data show that approximately 60 percent of the proposals have come from land grant universities, the traditional sites of research in agricultural sciences. In the past, much of the basic research in plant science in the land grant universities was conducted in the departments of biology, botany, and chemistry in the schools of science (for example, M. Calvin's Nobel Prize–winning work on the path of carbon in photosynthesis). The applications to CRGO show a shift of basic science into the schools of agriculture and the Agricultural Experiment Stations. Public universities that are not land grant schools submit 15 percent of the proposals, private universities 10 percent, and the USDA agricultural research laboratories 5 percent. The rest of the applications come from other federal laboratories, private nonprofit research foundations, and a few from profit-making organizations. The ratios of awards to applications from different types of institutions show that the scientists who applied from the various types of institutions are equally competitive. The Competitive Research Grants Program has reached a large group of scientists who generally have not had access to agriculture research dollars. These findings support the view that this open competitive grants program may be an effective link between the basic and applied sciences, as envisioned in its establishment.

Generally, the operations of the CRGO seem to have been satisfactory to the applicant community. There were more persistent expressions of concern from some of the administrators in the agricultural research establishment. Other public and private research organizations have lived with research grants for decades and feel more comfortable with a funding mechanism closely patterned on the NSF-NIH model. The Agricultural Experiment Stations have been supported by federal formula funds and state appropriations and were not as familiar with competitive grants as a mechanism for support of research. Although the disbursement of formula funds at the local level is an efficient mechanism for solving practical problems of a local or regional nature, many basic research problems are not local or regional, nor is the expertise for evaluating such projects always available locally. Few institutions can afford more than one researcher each in photosynthesis, nitrogen fixation, and so on. Thus the evaluation and disbursement of funds for basic research is frequently a national rather than a local process.

Table 1. Data on CRGO grant applications and awards.

Year	1978	1979	1980
Number of proposals	1109	861	600
Number of grants	197	193	206
Percentage of proposals resulting in grants	17	22	34
Amount requested ($ million)	250	134	93
Amount awarded ($ million)	14.4	14.550	15.035
Percentage of requested amount awarded	5.7	10.8	16

Many administrators in the experiment station system see the overhead charge levied by the institution against the grant as a loss of research funds. They are not alone, since nearly every grant winner who has learned of the overhead costs charged to grants feels some chagrin at the apparent loss of research dollars. However, the appearance of loss is more acute in the experiment stations, since formula funds have been protected by law from overhead charges. Still, the cost of doing research in a land grant university must be nearly the same whether it is done in the chemistry department or the experiment station; where the dollars come from (state or federal government) may be different. There seems no alternative to overhead charges, and they may yet be extended to the formula funding mechanisms.

Those accustomed to formula funds see the preparation of research proposals as an enormous burden in time spent in writing about research rather than doing it. All grant applicants would agree that minimizing the time spent in proposal writing is desirable. However, the estimates of a House Agriculture Committee investigative staff (*8*) that it may take up to 3 months to prepare a grant proposal and may cost up to $10,000 are overestimates of the effort invested by most applicants. All scientists doing research should be abreast of the status of their field and should have clearly focused ideas. While it is undeniably true that preparing a formal proposal requires time, this time is a small part of that needed to keep up with the latest events in a research field. Finally, one cannot imagine using tax dollars without documenting the objectives, methods, and results. The application for renewal of a competitive grant is a method for periodic evaluation of the continuing worth of the research.

It is frequently argued that grants are not an effective mechanism for supporting long-term research. A wealth of research opportunities and scarce dollar resources have prompted the CRGO to make most of its grants for 2-year periods. It is understood that many of these projects will require 10 years or more to be completed, and it is hoped that most will regularly win renewals. Of course, it would be better to make grants of longer duration, but this requires either a larger appropriation or legal authority, such as is used by NIH and NSF, to fund future year recommendations out of future year appropriations. The benefits of long-term assured support must weigh against the needs for accountability and for flexibility to exploit new opportunities. Some of the research goals addressed by the Competitive Research Grants programs may be substantially solved by the end of this century; others will continue beyond that time. As in the NIH and NSF programs, one expects that grants will be renewed repeatedly where the best progress is being made.

There is some unhappiness in the agricultural community with the program areas covered by the CRGO. Many of the areas in the traditional agriculture research establishment are excluded from support. The case of research on physical and chemical stress on plants has been mentioned. There seem to be excellent opportunities here, but the area may have been excluded for the practical reason that there would not be enough funds to create such a program. The USDA has for some years had special grants programs directed at shorter term goals in applied problem areas, but this kind of activity should not be confused with the support of long-term basic research. Recently there has been intensive effort on behalf of animal science research and an effort to gain increased support for schools of veterinary medicine. The basic research community feels the need for more grant programs, and the applied science communities in agriculture and in engineering are pressing new claims for support. These claims may have much merit, but to start and stop programs in short cycles would satisfy no purpose.

A few administrators of agriculture research in both the experiment stations and federal laboratories have expressed concern that research grants to individual investigators lead to loss of control of research. Although, as noted earlier, there is an advantage to local control of research on some immediate technical problems, basic research problems are best defined by and evaluated in the larger community. Some administrators in the agricultural community have welcomed external competition as a stimulus to their research staff, as well as the access to a new funding source. Further, basic research seems to prosper by minimizing administrative direction and maximizing the opportunity of the investigator to exploit new opportunities. Loss of administrative control of investigators with individual project grants was experienced in medical schools and schools of basic science in the 1950's without enduring detriment to the work of these institutions.

Accomplishments of the Competitive Research Grants Office

Although the CRGO was charged with supporting long-term basic research efforts underlying agriculture, one can discern some substantial accomplishments after only 3 years of existence. The value of such progress lies much in the eye of the beholder. The report of the House Agriculture Committee Investigative Staff gives warning that renewal applications must document success to justify the continuance of the grants program (*8*). One must hope that success will be measured in terms of scientific progress as well as of increased agricultural yield per acre.

There are many examples of scientific success that appear in the renewal applications. Two are mentioned here as examples of the application of modern techniques of molecular biology and genetic engineering. Bogorad and co-workers (*9*) have been studying the genetic material in the photosynthetic structure—the chloroplast genome. They have isolated, cloned, and sequenced the gene for the large subunit of the enzyme ribulosebisphosphate carboxylase. This enzyme catalyzes the first step in carbon dioxide fixation and is believed to be the most likely site of manipulation to increase photosynthetic yield. Although it seemed that many years of conventional protein chemistry would be required to learn the amino acid sequence of the large subunit of this enzyme, Bogorad's work revealed the nucleotide sequence for the gene that codes for this protein, and the amino acid sequence could be deduced from it immediately. The gene was sequenced in less than 6 months. Cloning the gene for this component of photosynthesis opens the way to manipulation of the enzyme structure by genetic engineering, which will lead to a better understanding of how the enzyme works and could lead to the design and production of a functionally improved enzyme. A second example of success in a CRGO-supported project is research of Haselkorn and co-workers (*10*). In this case, the gene for a key enzyme in nitrogen fixation was isolated, cloned, and sequenced. The grants did not create all the techniques for these accomplishments, but they did provide expanded support for research at a time when great opportunities were appearing. There are other examples of research that may have more immediate practical results in areas such as fruit breeding, insect pest control, and diagnosis and control of human nutrient deficiency.

Another sort of evidence of the effect of increased support for plant science research was an increase of 10 percent in the number of manuscripts submitted to the *Journal of the American Society of Plant Physiologists* in 1980 (*11*). In 1980, many manuscripts began to acknowledge the support of the CRGO.

Other evidences of the success of the programs include the fact that many of the applications to the CRGO come from departments of applied agriculture where, in the past, little or no basic science had been done. This indicates better integration of basic and applied science. Also, with its ability to make grants to other federal laboratories, the CRGO can help to nudge the science there toward the mainstream of research. Where formerly federal scientists were denied access to and so protected from the competition for research grant funds, they now have the opportunity to expand their research and measure their effectiveness against the broader community of researchers.

There is evidence of a testimonial sort that graduate students of high quality are applying in unprecedented numbers to work in the research areas served by the programs of the CRGO. This may be less the result of a government program than a response to the popular press, which makes the needs for increased agricultural production of food and renewable energy resources evident to undergraduate students. At present, there is a demand for students trained in these research areas as the agricultural chemicals industry prepares to exploit the technical opportunities of genetic engineering of crops, the regulation of photosynthesis and nitrogen fixation by rational means, and the control of biological stress on crops by environmentally sound procedures.

Considering these promising beginnings and the bright prospects for the future of this research, we hope that government support can continue. The original impetus for the CRGO persists. In the *New York Times* of 8 November 1980, a brief article described the drawdown in world grain reserves to their lowest level since 1975. Another poor to middling crop year in many countries could mean disaster for many of the world's people.

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