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NATIONAL PRODUCTION PROGRAMS FOR INTRODUCING HIGH-QUALITY PROTEIN MAIZE IN DEVELOPING COUNTRIES

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NATIONAL PRODUCTION PROGRAMS FOR INTRODUCING HIGH-QUALITY PROTEIN MAIZE IN DEVELOPING COUNTRIES

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Spurred by the needs of a protein-hungry world, maize research has moved rapidly over the past 10 years. Maize breeders, biochemists, and nutritionists have combined their efforts to develop maize varieties and hybrids that are nutritious, economical, and universally available. Since Mertz, Bates, and Nelson reported the enhanced nutritive quality of opaque-2 maize in 1963, the potential of this high-quality-protein food source has been studied rigorously and with increasing success.

Over the past few years workers have converted many diverse and variable maize populations with inherent supplies of modifiers, and they have selected for a wide range of characteristics in many environments to provide the germ plasm base for high-quality-protein varieties and hybrids. Now cooperative international testing of the new materials—at 54 sites in 24 countries in Asia, Africa, and the Americas—indicates that several varieties are fast approaching commercial standards.

This rapidity of progress at the research level suggests that we must now mount an effective campaign for the adoption and production of the new maize varieties on a global basis, thus sharing their benefits with the nutrient-poor people of the world. However, we must plan well. Although there is no blueprint for a system that will match the needs of every country, some general guidelines can be proposed. Successful experiences in some countries and regions can be adapted to other areas. And, hopefully, the unsuccessful projects in some nations can be used to prevent repeat performances.

One factor seems certain: if the world is to realize the potential of high-quality-protein in maize, there must be a continuous flow of genetic materials into and among the national maize programs. National efforts must be more sharply defined and national staffs must be allowed more opportunities to participate at an international level, thus becoming aware of and having access to the best materials and ideas.

The following outline of maize program requirements illustrates some points of focus for national programs. Organizational and structural limitations are cited, and the final section is devoted to model staffing patterns.

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ROLE OF NATIONAL PROGRAMS

The ultimate success of high-quality-protein maize depends upon the communications effectiveness of researchers, and their ability to convince national governments of this crop's importance. We scientists, in our traditional, conservative approach, too often have been poor communicators, at least when our efforts have been measured on a mass scale. We tend to be more concerned with relating our findings to other scientists than we are with applying the information at the production level.

Today, we face the challenge of redirecting our thinking and study toward more global needs. We must first convince government planners and policy shapers to make a firm, general commitment in support of agricultural research and production programs. Then, in appropriate countries, we should urge that high priority be given to planning and organizing maize programs.

Historically, however, governments have not placed a high priority on food production until their countries faced famine conditions, or until the cost of importing food reached a level that made self-sustained production the most attractive political and economic alternative. Government commitment is essential; only with this support can an effective national program be organized within the economic means of a country.

RESEARCH AND PRODUCTION PROGRAM LIMITATIONS

National programs usually have several initial limiting factors, including (1) lack of qualified research and production personnel, and (2) lack of an organization structure to effectively generate the technology and extend it to the farm production level.

As outlined later in this report, most countries will require a minimum of 10 to 15 years to develop self-sufficient staffing patterns. Staffing demands often would require that a large portion of a nation's agricultural graduates enter into the production system for a single crop (maize). Governments rarely appreciate the cost and time necessary to staff an agricultural institution. Too often, national planners find it easier to estimate production targets, rather than plan for an effective research and production program with the staff development necessary to reach production targets.

Other factors to be considered are the following:

1. Budgets for national programs, although extremely important, are seldom the initial limiting factor. Similarly, credit is rarely the first limiting factor to accelerated production, although it often becomes a restraint as production increases.

2. Stable and fair prices for production inputs and for the harvested crop are extremely important. In far too many countries the ratio of the cost of fertilizer to the value of the crop does not provide sufficient economic incentive. Without this profit motive, the best of research and production efforts will have little effect in increasing production.

3. Unavailability of fertilizers and insecticides at the right place and the right time can be a hindrance. Often these supplies are managed by government workers, and their services vary from one country to another. Presents systems seldom work well. Many of the inadequacies in planning are due to inaccurate advice from the agricultural sector—sufficient provisions are not anticipated, particularly as production increases rapidly.

4. Understanding of agriculture and the changes that are taking place or could take place is frequently lacking. In my opinion, every country should have a competent production economist who can communicate effectively with the agricultural staffs and with national planners.

NEW APPROACHES

1. Here at CIMMYT we feel strongly that national planners should move away from the traditional systems of agricultural organization built around the academic disciplines. We feel that the older systems should be reorganized into crop-oriented teams. In the past, industrial crops such as rubber, which have been researched by a crop-oriented team, have proved much more successful than food crops, which usually have not been studied by a team of researchers. Maize has been very productive in the United States, perhaps because U.S. seed companies have had their own research and production teams working on the single crop.

2. Means must be found to bring together effective research and extension teams. Extension and production personnel should be crop-oriented, also. For example, they might devote their work to maize during the maize season and, later, to some other crop grown in rotation with maize. It is essential that extension agriculturists be allowed to devote their full efforts to increasing production, rather than diluting their agricultural work with the many community responsibilities traditionally assigned to extension personnel.

In some countries, extension is staffed with the less-qualified workers, or with agricultural graduates having lower academic records. The best-qualified people go into research. Also, the extension staffs usually receive lower salaries and have fewer promotion opportunities. These discrepancies must be eliminated if extension efforts are to be effective.

The subject-matter-specialist concept does not fit the pattern of most national extension systems. In my opinion, the production-specialist role is essential, and specialists should be assigned to work from experiment station bases, in close liaison with the extension field staff.

3. Pilot projects must be assessed for their potential contributions to the value of a new material, idea, or concept. Some such projects have been successful in the past, but generally they have not been integrated into a truly national program; therefore, pilot projects have had little influence on total national production. Too often they have been expensive and unproductive exercises. *There is no substitute for commitment to national programs.*

4. Maize varieties, not hybrids, should be used in developing countries unless there is a private seed industry capable of producing and selling seed of high quality. Few government-sponsored hybrid seed production programs have proved to be efficient.

Such a situation should not be surprising. Varieties can be developed more rapidly than hybrids. In the same time that lines, single crosses, and hybrids can be increased and ready for sale, further improvements can be made in varieties. Thus, the yield advantage normally assumed with hybrids is often lost.

Hybrid seed programs have a further disadvantage in that as many well-qualified people are required to produce quality hybrid seeds as are needed to develop the hybrids. When few qualified people are available, a nation can ill afford to dissipate its resources with hybrid seed production.

5. In some countries, seed certification, plant quarantine, and variety release policies are nonexistent: in other countries these policies are so strict that they hamper production. In my opinion, production increases should receive the highest priority: seed certification and release policies are not necessary if an appropriate testing program is used. Unfortunately, many developing nations now are being encouraged in an unwise use of time, money, and people to develop and enforce seed control regulations.

PROGRAM STAFFING

Having described some of the limitations, as well as some possible new approaches for national crop programs, we now turn to a description of a model that outlines some of the staff structure and functions for such programs (see Table 1).

One headquarters station and four regional stations will meet the research needs of most nations, with a staff of 20 scientists required to staff the headquarters station and a staff of 6 for each regional station a total of 44 people. Degree requirements for the staff could be a minimum of 6 Ph.D.'s, 10 M.S.'s, and 28 B.S.'s. or the equivalent. In addition, there should be five subject-matter specialists with M.S. degrees for extension work, with one specialist posted at the headquarters station and one at each of the four regional stations.

The coordinator is responsible for the coordination of all research and production activities at the headquarters station and the regional stations. He also is an active researcher on the team and may be trained in any of the disciplines. He must understand and implement the concept of a true team. (My concept of a team is a group of people working together and not a group of people who are "cooperating". When people cooperate they usually maintain their own special interests, and their cooperation involves provision of an insecticide or assistance with note taking. The concept here

TABLE 1. Model for national crop programs

Research staffing pattern for headquarters			
1 coordinator	Ph.D.	2 research assistants	B.S.
1 breeder	Ph.D.	1 pathologist	Ph.D.
1 associate breeder	M.S.	2 research assistants	B.S.
3 research assistants	B.S.	1 entomologist	Ph.D.
1 research agronomist	Ph.D.	2 research assistants	B.S.
(a team without individual disciplinary programs)			
Production staffing pattern for headquarters			
		1 production agronomist	M.S.
		2 research assistants	B.S.
		1 agricultural economist	Ph.D.
		1 research assistant	B.S.
		1 subject-matter specialist	M.S.
Staffing pattern for regional stations			
		1 research agronomist	M.S.
		2 research assistants	B.S.
		1 production agronomist	M.S.
		2 research assistants	B.S.
		1 subject-matter specialist extension	M.S.

involves a team of people with one captain. The entomologist, for example, need not have special trials for entomology. He could do insecticide evaluation as part of the overall crop production management program. In rare cases he might find a need to test new chemicals).

A simple, effective program must be worked out that can be executed by available staff, since a program in most countries would have to start with a few, inadequately trained people. As staff numbers increase and capabilities improve, the program enters into more complex research activities.

In the initial stages, when local trained staff are unavailable, a well-trained foreigner, who has the qualifications to function as the *coordinator,* might be invaluable and could greatly accelerate the progress of the national program.

The program should start by testing quality protein varieties and progeny that can be supplied by the more advanced international and national programs. It seems likely that varieties could be identified that will be successful in many countries. Of the thousands of progeny that might be tested it seems certain that a few would be superior for the local ecological conditions. These progeny could be put together as a variety.

To identify varieties and progenies successfully, experiment stations must have efficient testing facilities. A high degree of skill and carefully conducted yield trials would be required to provide the conditions under which the superior materials could express their genetic potential. Variety and progeny testing could be done at all headquarters and regional stations.

The agronomic research would start by assessing management practices, including fertilizer response, rates of insecticide applications, optimum plant population, and planting date, as well as other specifically useful factors. In addition, the production team would start regional farm testing. This would involve testing two or three of the best varieties, at two or three levels of the production variables as determined on the experiment station. The regional farm testing should be done with cooperative farmers on their own land.

Through a regional farm testing program, the farmer could be involved in selecting superior varieties. By participating in the testing program, he could see which levels of fertilizer and which variety might be most successful on his farm. It is highly important that the farmer become interested and self-convinced through personal involvement. Field days at harvest with the help of neighboring farmers could aid to relay information and to show the results of a successful production demonstration program.

The subject-matter specialist could help identify cooperative farmers and provide support for the regional farm testing. He also could organize the extension personnel, helping to prepare large production demonstration plots of at least 0.5 hectare. The production demonstration plots would provide a showcase for the best variety, using optimum economic production practices.

Field days could be held at harvest time at each of the production demonstration plots. If the technological "package" is sound, the farmer growing the demonstration plot will be enthusiastic and might become an excellent "extension" agent. Since the production demonstration plot would be at least 0.5 hectare in size, the center of the field could be saved for seed. The subject-matter specialist and the extension staff should participate in the harvest and explain the reason for saving only isolated seed from the center of the plot. This seed should then be sold to the neighboring farmers.

CONTINUOUS FLOW SYSTEM

The process, or flow system, of variety and progeny testing on the experiment stations, regional farm testing, and production demonstration plots is continuous, with new materials and new farmers. It is critical that all steps be managed with precision and be successful. In this way, relatively large quantities of new seed will be moved rapidly into the area.

The experiment station will have to increase rather large quantities of genetically pure seed of any variety that goes into the production demonstration plots. Since the variety that will prove to be best is not known in advance, all varieties in the regional farm testing program should be simultaneously increased on the experiment stations.

Figure 1 shows the flow system for materials and technology among headquarters station, four regional stations, five regional farm testing sites operated from each station, and five production demonstration plots in the vicinity of each regional farm trial. The staff patterns outlined previously could manage this colume of work. Production demonstration and seed increase blocks would be planted at the rate of 125 per crop season in the first years of the program. In subsequent years these numbers would probably be insufficient to meet the nations' requirements.

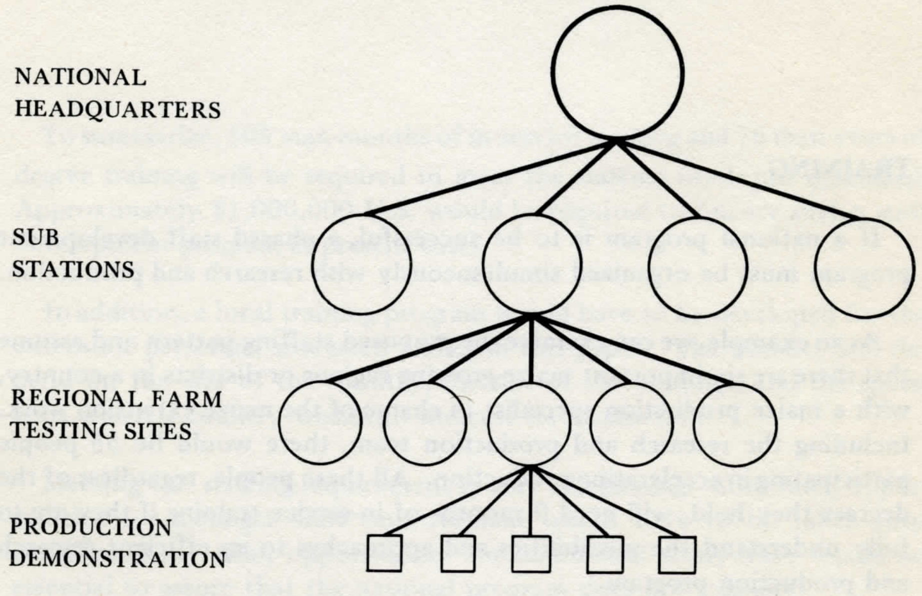

FIGURE 1. Flow system for materials and technology.

As indicated, extension workers must become better trained and more involved. Several maize production specialists might be trained simultaneously with the development of the research staff, and then posted throughout the maize-producing area of the country. There should be at least one specialist for every administrative division or region of a country. His responsibility would be to organize the extension staff working in his area for successful demonstrations and to explain the advantages of the new high-quality-protein maize varieties to the farmers. Along with the subject-matter specialist, he would organize training programs for the the production staff conducted by the research staff at the experiment stations.

Although researchers and extension people might understand the value of the quality protein, it might be difficult to explain this concept to the farmer. The value of quality protein in the family diet cannot be perceived rapidly enough for parents to appreciate it during a short time. Therefore, any variety going into production must be superior in yield to the variety previously grown, and it must be acceptable in appearance.

In some countries, swine trials might convince farmers of the value of new varieties. For example, swine fed normal maize will reach market weight in about 10 months on the average. However, if fed the same amount of high-quality-protein maize, the swine would reach market weight much more rapidly. Therefore, swine-feeding programs could be started with farmers wherever production demonstration plots are grown. If the farmer feeds half his pigs with high-quality-protein maize and the other half with normal maize, he will see very quickly the feeding value of the quality protein maize. This simple demonstration could be one of the most effective teaching tools available to promote the growing of quality protein varieties.

TRAINING

If a national program is to be successful, a phased staff development program must be organized simultaneously with research and production.

As an example, we can examine the proposed staffing pattern and assume that there are six important maize-growing regions or districts in a country, with a maize production specialist in charge of the maize extension work. Including the research and production team, there would be 55 people participating in accelerating production. All these people, regardless of the degrees they hold, will need 9 months of in-service training if they are to fully understand the possibilities and approaches to an efficient research and production program.

If we assume that a B.S. or equivalent degree could be obtained within the particular country, a phased staff-developed program within a 14-year period could include the approximate numbers of people indicated in Table 2.

It can be readily seen that the staff development program is ambitious. In most countries, this sort of staff would be difficult to mobilize on such a schedule.

However, when this training schedule is completed, the program should be able to meet national research and production requirements. Governments should understand that resignations, promotions, and other causes will reduce this initial staff up to 25%. Therefore, more people must be trained over a longer period of time.

TABLE 2. Personnel for staff-development program

Year	1	2	3	4	5
In-service training	10	10	10	10	10
M.S.	2	4	4	4	4
Ph.D.	0	0	0	2	4
Year	6	7	8	9	10
In-service training	5	—	—	—	—
M.S.	4	4	4	4	4
Ph.D.	4	4	4	4	2
Year	11	12	13	14	—
M.S.	4	4	4	2	—
Ph.D.	0	0	0	0	—

To summarize, 505 man-months of in-service training and 76 man-years of degree training will be required to meet the staffing needs just described. Approximately $1,000,000 U.S. would be required to finance such a staff development program at present costs.

In addition, a local training program would have to be developed for the extension personnel discussed earlier in this paper. The number will depend on the size of the country, the size of the holdings, and the speed with which a country wishes to increase its production.

Meeting the staffing requirement is only a beginning. Continued opportunities for younger staff improvement would have to be taken into consideration. Also, opportunities for senior-staff study leave would be essential to assure that the national program does not stagnate.

The system described in this paper is not intented as an "absolute" model, but it does provide an outline for a successful program. Although the outline is built around high-quality-protein maize, it is not maize specific. The model is equally applicable to other national crop programs.