Some Critical Requirements for Productive Agricultural Research

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The International Service for National Agricultural Research (ISNAR) began operating at its headquarters in The Hague, Netherlands on September 1, 1980. It was established by the Consultative Group on International Agricultural Research (CGIAR) on the basis of recommendations from an international task force, for the purpose of assisting national governments in strengthening agricultural research. It is a non-profit autonomous agency, international in character, and non-political in management, staffing, and operations. Most of its funds are provided by an informal group of approximately 30 donor countries, development banks, foundations, and other international organizations which make up CGIAR.

ISNAR is the youngest of the 13 centers in the CGIAR network, and it is the only one which focuses primarily on national agricultural research issues. It provides advice to governments, upon request, on organization, planning, manpower development, staff requirements, financial and infra-structure requirements, and related matters, thus complementing the activities of other assistance agencies. Additionally, ISNAR has an active training and communications program which cooperates with national agricultural research programs in developing countries.

ISNAR also plays an active role in assisting these national programs to establish links with both the international agricultural research centers and donors.

Citation: Mosher, A.T. 1982. Some Critical Requirements for Productive Agricultural Research. The Hague, Netherlands: International Service for Agricultural Research.

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May 1982

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Foreword

This booklet is the first published contribution of ISNAR to the methodological literature of agricultural research management. We view this area as a fundamental part of our mandate. The printed word — in booklets such as this, in occasional papers, possibly in newsletters, and various other ways to be developed — can disseminate widely the useful knowledge that accrues to ISNAR as a result of our interactions with scholars, managers, and interested persons throughout the world.

We are especially privileged to inaugurate this publications series with a work by Dr. Arthur T. Mosher. Many in our field of interest are already well acquainted with his work. Often on field missions we have seen his books on shelves in both central and remote field stations. Few persons can bring to such a writing task the unique talents that characterize Dr. Mosher. Many decades of working experience, much in less-developed countries, have assured a practical turn of mind; his sensitivity to people over the widest social-cultural spectrum causes him to write meaningfully and directly to his readers; and a lifetime association with academia has developed in him the methods and standards of the scholar.

Dr. Mosher has synthesized here a list of 15 key requirements for productivity in agricultural research. His orientation is strongly toward the research manager in a developing country, and we believe his advice will be adaptable to many of the situations faced by the persons filling those crucial roles today. We invite feedback, especially from research managers whose problems Dr. Mosher has addressed.

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Director General
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There is now general agreement that agricultural research is one of the basic requirements for achieving rapid agricultural growth in any country. Unfortunately, there is not as widespread an understanding of (1) the great variety of agricultural problems which need research; (2) the several types of research activities which are appropriate for these different problems; and (3) what it takes to make agricultural research highly productive.

Agricultural research needs to be focused on three types of problems:

- how to increase the production of individual farm commodities and the productivity of total farming systems,
- how to improve the rural agri-support services that provide farmers with the facilities they need in order to increase production, and
- what changes in national policies would increase farmers' incentives to increase production.

Too frequently, the term "agricultural research" calls to mind only the first of these three types of problems. Research on technologies to be used on farms is certainly important and should always receive major attention. But the other two types of problems need research attention also. Unless rural agri-support services are strong and efficient, and national policies affecting farmers' incentives are favorable, farmers may be unable or unwilling to use all of the production opportunities that improved farm technologies make available.

Thus, in this paper, by "agricultural research" we shall mean all systematic efforts to develop (a) more productive farm technologies, (b) organizational forms and operating procedures for agricultural support services, and (c) national policies that can accelerate agricultural growth.

The propositions advanced in this paper have to do primarily with the first of these three types of research, but the other two must not be forgotten.

Agricultural research can be highly profitable. A number of studies in various countries have estimated rates of return on investment in certain types of agricultural research that range from 22% to 90% per year. But it is important to realize that those phenomenal figures do not mean that every research project is a good investment. Resources have been wasted in many countries on activities that were called research, but which actually produced nothing at all. Good research can be highly rewarding; poor research is useless. Consequently, an alternative title for this paper might well have been "Achieving Quality in Agricultural Research."

With increasing recognition of the importance of agricultural research, more and more has been written about it in recent years, and many conferences have been devoted to discussing it. What, then, can be the reason for writing still another paper?

First, most publications on this topic have been written by and for research scientists. Such publications are useful and important. But building national research systems depends to a considerable degree on decisions by public officials and general administrators who have not had personal experience in research programs, and who do not realize what is necessary for such programs to succeed. For such persons, a brief overall introduction to the topic may be useful.

Second, even persons who have had personal experience in conducting research may need a checklist to remind them of major considerations in planning and conducting total research programs.

They were trained as specialists in how to conduct particular types of research, but not in how to create the organizational and administrative climate that fosters good agricultural research, including designing research projects that recognize the interdependence among scientists having different specialized interests and training. All of them need to understand each other if they are to work together to meet the research needs of their country.

Creating and operating a productive agricultural research program is a complicated undertaking. It involves setting up one or more organizations that are appropriate for the distinctive task of conducting research and suited to the administrative and political climate of the country in which it is located. It involves marshalling the physical facilities of laboratories, experimental plots, and other equipment that productive research requires. It must include adopting styles of administration that meet the particular requirements of research activities. It requires appropriate procedures for training and retaining competent researchers. It involves developing and maintaining effective communications among research workers, extension agents, policy-makers, and

farmers. It requires effective procedures for choosing what research projects should be undertaken and how the energies of scarce research scientists are to be allocated to different projects.

The requirements are so numerous that they cannot be treated adequately in any one publication. Consequently, ISNAR is in the process of preparing separate statements of the needs involved in each of them. However well that may be done, there is still a need for a brief overall statement that brings together a few of the key requirements that are so important, and so frequently neglected, that they need to be highlighted. The purpose of this paper is to draw attention to those outstanding needs.

This paper is presented as a set of propositions for discussion. Some of them are elementary and are likely to be quickly accepted; others will need to be debated. Each addresses an important topic. If there is disagreement about a proposition as stated, how should it be revised to be appropriate in a particular country?

Propositions for Consideration

1 *The first requirement for productive agricultural research is that it must be conducted by specially trained research scientists.*

Many countries, where leaders were convinced that they needed agricultural research, have rushed into launching it, assigning persons as research officers who had not had more than B.Sc. training. That is a mistake. Productive research always requires researchers who are well-trained for the task: some at the Ph.D. level, some at the M.Sc. level, and all of whom have continuing opportunities to improve their research skills. Research is no task for amateurs!

One reason for the high degree of success of some research activities in recent years has been that they have employed highly sophisticated research methodologies. These are techniques learned largely in university studies at the Ph.D. level. It is only at that level, or later in a scientific career, that they can be mastered.

Persons with less training can often be helpful in carrying out certain research projects if they work under others who have had advanced training. And it is true that persons with Ph.D. training often prefer to confine themselves to conducting sophisticated research that can lead to publication of results in international scientific journals, even when a considerable amount of simpler research is of higher priority. The solution to that problem, however, is not to staff research organizations with persons with less training. It is, instead, to persuade researchers to devote themselves to resolving whatever are the country's most urgent problems and to reward them accordingly.

The need for well-trained researchers gives rise to an important corollary. It is that provision must be made for paying salaries high enough to recruit and retain such skilled scientists. Over and over again, fellowhips for postgraduate studies have been awarded on the assumption that, after training, those persons would be recruited to staff agricultural research organizations, only to have them lured away by higher salaries offered by domestic or international public or private agencies. The world recognizes the value of highly trained scientists, even when some administrators in ministries of agriculture do not.

2 *Productive agricultural research requires participation by research scientists, each of whom has been trained in a particular scientific discipline.*

There is no such thing as an "agricultural scientist." There are only plant geneticists, plant pathologists, entomologists, plant physiologists, agricultural economists, soil scientists, agricultural engineers, sociologists, animal nutritionists, animal pathologists, anthropologists, geographers, and others. Each of these disciplines has its own specialized set of research methodologies. Each, therefore, can analyze some particular kinds of problems, but not others.

It usually is not possible for a national agricultural research staff to have specialists from all related disciplines at the beginning. Nor are all required for a successful attack on certain high priority problems. But the fact must be faced that the training and the tools of research scientists are highly specialized. Each research scientist has certain relevant skills and many blind spots. This is what makes team research so important in tackling many agricultural problems.

3 *A third requirement is that each research team, and each research organization as a whole, needs to consist of a minimum critical mass of research scientists.*

Scientists from at least five to eight agricultural science disciplines, and at least two scientists in each, is probably the minimum critical mass for any serious research effort.

In a commodity-oriented research program, for example, it usually cannot be known in advance how much contribution to increasing production of a particular commodity can be achieved through plant breeding, how much by bringing certain diseases under control, or how much through changing agronomic practices. Nor can it be predicted whether a particular disease can most economically be controlled chemically or through breeding for disease resistance. It is only by assembling a team with varied disciplinary backgrounds, and by their working together, that these questions can be answered.

Another phase of the importance of a critical mass flows from differences of ability and of points of view among research scientists. It is better to have two or three soil scientists, two or three plant breeders, etc., than only one of each. One person may catch what another misses. They may favor different approaches to a problem, in which case it is better to try two or three of the approaches than to settle in advance on one (which may not be the best).

As the number of problems to be tackled simultaneously increases, and as the number of districts increases in which commodity production programs and farming district projects [1] require on-

[1] *A.T. Mosher, "Three Ways to Spur Agricultural Growth," (New York: International Agricultural Development Service, 1981.)*

farm testing and local adaptive research, the number of research scientists required rises rapidly. Where this requirement for a minimum critical mass cannot immediately be satisfied, two initial steps are indicated. One is to tackle only simpler types of research that are within the competence of those few well-trained researchers who are available; the other is to accelerate the training, some to the Ph.D. level, of additional research scientists.

4 *It is a corollary of the preceding requirements that research agencies need a type of organization that encourages staff interaction.*

Research agencies have usually been organized with a separate department for each discipline. While that has certain advantages, it has limitations as well. It may or may not encourage staff interaction within disciplines, but it almost always discourages interaction between disciplines.

Representatives of each discipline get well acquainted and may compare notes, but representatives of different disciplines seldom meet, especially in large organizations.

To overcome that handicap, certain of the international agricultural research institutes have foregone having departments at all; they organize by ad hoc programs and projects, temporarily assigning to each the requisite number of scientists of different disciplines. Staff interaction takes place within each project.

Another method is to schedule frequent staff seminars, attended by all research scientists, subordinate staff, and trainees. In each such seminar a progress report on a particular project is presented and is thoroughly discussed by all.

5 *Productive research requires a style of administration which emphasizes leadership more than authority.*

Highly trained research scientists have been encouraged by their single-disciplinary training to work alone. Most of them have been trained in universities where *basic* research has the highest prestige. They tend to be highly independent, wanting to select their own topics for research and their own ways of working. It is not easy for them to adapt their professional behavior to working as members of teams, working on *applied* research problems emerging out of efforts to increase farmers' production of high-priority commodities.

Most research scientists feel most comfortable in laboratories or on experimental farms. The idea of on-farm testing, with its lack of uniform plots and rigid controls, appalls them.

Under these circumstances, the style of administration in research organizations becomes critical, and leadership becomes more important than authority. The administrator must find ways to bring all research scientists into the process of selecting the projects to be pursued and the methodologies to be used. He must develop operating procedures that build and maintain high morale — enthusiasm for what the entire organization is doing. Authority can make only minor contributions, or is often counterproductive, with respect to these requirements.

It is because the leadership role is so important that the director of any research organization should be fully qualified to be a research scientist himself. Only such a person can command the professional respect of his staff.

6 *Productive research requires appropriate selection of research projects.*

Having achieved a critical mass of research scientists, each trained in a particular discipline, and having established a type of organization that encourages staff interaction and a style of administration in which leadership predominates, what research should be undertaken?

The research needs of each country are innumerable. Competent research scientists are scarce, and they are specialized. We can raise two questions, the answers to which should be paramount in deciding what research projects to undertake at any particular time:

What current problems of farmers or of the national economy most urgently need research attention?

For what research projects are adequately trained researchers now available?

One always wishes that only the first of these questions need be considered. In practice, however, the second frequently must also be taken into account. Every available research scientist should be kept busy on projects to which his skills are relevant. Among the projects which present researchers are competent to undertake, those should be chosen which are of the highest current priority to farmers and to the country. No project should be undertaken just because the problem is important; it is necessary also that conducting the particular project successfully is within the competence of the research personnel who are available.

Other important criteria include: (1) the length of time before useful research results can reasonably be expected to become available

and (2) the estimated cost and benefit of the project. Not every long-term or expensive project should be rejected. Some of them should receive high priority. But the time required and the anticipated cost should always be taken into account.

Who is to decide what projects are to be undertaken, and what procedures are to be followed in making such decisions? Research scientists need to be involved because they are in the best position to judge what projects are feasible, how long projects need to last, and how much projects may cost. Farmers and field agricultural officers need to participate because they are best acquainted with farmers' urgent needs. Research administrators should manage and participate in the process through which projects are selected, but they should not make the decisions by themselves.

This whole question of how to select research projects is complex. It has received considerable attention in recent years. However, most of that attention has been devoted to large research organizations and to those in developed countries. [2]

Too little thought has been given to project selection in research programs of modest size in countries still trying to achieve a modern agriculture.

[2]*Walter L. Fishel, ed., Resource Allocation in Agricultural Research, (Minneapolis: University of Minnesota Press, 1971).*

7 *A seventh requirement is that research scientists have appropriate scientific instruments, equipment, and other facilities with which to work.*

Equipment. A common mistake in drawing up research budgets is to assume that all that is needed is competent research staff and freedom for that staff to engage in research. That may be true for a few types of primitive research, but most agricultural research requires a considerable amount of equipment as well: weighing instruments; microscopes; appropriate data processing equipment; weather monitoring instruments; arrangements for careful control of sunlight, temperature, and humidity in greenhouses; calculators; and other research equipment.

Experimental farms. Not least among these needs is that for carefully laid out field plots with provision for precisely controlled irrigation, measurement of plot areas, uniform growing conditions, and easy access for cultivation equipment. In on-farm testing, it is important to take conditions as they come, accepting non-uniformity of fields just as farmers must deal with them. But in experiment station research carefully prepared field plots are essential.

Laboratory and field assistants. Much agricultural research involves a considerable amount of more-or-less routine laboratory and field work that can be carried out by persons who do not have all of the skills of a research scientist. It can be carried out by less highly paid laboratory and field assistants, provided that they are trained for their specific tasks. It is a mistake, however, for too much of the routine laboratory and field work to be delegated to assistants. By actually doing some of the routine work themselves, research scientists can catch important clues that might be missed by less-well-trained assistants.

Staff mobility. Much of the work of research scientists needs to be done at experiment stations where well-equipped laboratories, greenhouses, and experimental field plots are available. But much also needs to be conducted away from such stations in connection with on-farm testing and district adaptive research, and in responding to calls from extension workers for help with respect to emerging problems. To make that possible, adequate transport facilities are necessary so that research workers can travel freely, unencumbered by lack of vehicles or by involved procedures for getting permission to travel.

Library facilities. Research scientists desperately need access to the broad world of knowledge previously discovered by other scientists, methodologies already developed, and information about what is currently being done by other agricultural scientists throughout the world. They may need to work in locations that are physically isolated, but they must not be asked to work in intellectual isolation. They may benefit from occasional travel to consult with other scientists — and provisions should be made for that; but they should be able to tap world knowledge quickly by simply going to the library. Thus, well-equipped research libraries, adequate budgets for new acquisitions, and the services of trained librarians are among the most important facilities required for productive agricultural research.

Budgets. To meet all of these requirements for productive research, it is important that budgets for these supporting services be adequate. This means that normally less than half of the budgets of research agencies should be to meet the salaries of research scientists. There is no point in having competent scientists unless they have the tools they need in order to be productive.

8 *Productive agricultural research usually requires a combination of experiment station research, district adaptive research, and on-farm testing.*

For too long it was assumed that experiment station research, by itself, was adequate and that the results of experiment station research could confidently be recommended to farmers.

But farmers not only deal with various types of soils; they also deal with risks and uncertainties not encountered on experiment station plots where all factors affecting production are carefully controlled.

In recent years, however, it has been found that on-farm testing and district adaptive research need also to be part of productive crop research.

Experiment station research is critical in experimental plant breeding, in developing disease controls, and in other investigations for which laboratory and greenhouse facilities are needed. *On-farm testing* is essential to gauge the local adaptability of experiment station results and to identify the localities for which additional adaptive research would be useful. It is when local testing reveals that experiment station results are not locally advantageous that *district adaptive research* is indicated. For example, it was discovered in the Puebla Project in Mexico that maize varieties thought to be superior were not, in fact, better than varieties already grown locally; adaptive research within the project area then established that yields could be improved through increasing plant populations per hectare, changing sowing dates, and changing the composition of the fertilizers being applied.

Well-trained researchers are as essential in on-farm testing and in conducting district adaptive research as they are at experiment

stations. That deserves to be emphasized. Laying out experiments for either on-farm testing or district adaptive research, and interpreting the results of those trials, both pose complicated problems that require expert participation. Techniques with respect to these problems are still being evolved. They are complicated, but progress is being made.

9 *Research undertaken in connection with accelerating agricultural growth needs to include experimentation to improve rural agri-support services and research related to national policies affecting agriculture.*

There is a natural tendency to equate agricultural research with research related to improving farm production technologies. Indeed, improving farm production technologies is absolutely basic. But that alone is not enough. Recognizing that farmers must also have access to efficient local and district agri-support services if they are to move ahead, leads to the conclusion that those agri-support services must be improved if possible.

To that end there is a type of experimentation that can be helpful but is too little used. It is what can be called "administrative experimentation." Where new agri-support services are to be established, or old ones improved, the usual procedure is either (1) to apply — uncritically — patterns of administration already in use or (2) to discuss alternatives and then decide among them without actually trying all of them out in the field.

An alternative is to select several operational patterns for trial, and try each out in a different farming district. [3]

[3] *A.T. Mosher, "Administrative Experimentation as A Way of Life for Development Activities," in Thinking About Rural Development, (Agricultural Development Council, 1976), pp. 65-73.*

Experimentation with respect to agri-support services is seldom conducted by research organizations engaged primarily in research on farm technologies. Instead, it may more logically be done by action agencies responsible for developing agricultural support services, and perhaps by universities in some instances.

Research with respect to national policies affecting agriculture also tends to be neglected. In some cases, universities and planning agencies are appropriate places to conduct such research — universities because they may be slightly less exposed to political winds, and planning agencies because they, too, need to be concerned about such policies. Provision for this type of research should certainly be made somewhere within a nation's total agricultural research system.

10 *Wherever accelerating agricultural growth is an important need, applied rather than basic research should be stressed first.*

Many research scientists object to this judgment, pointing out that productive applied research must be based on the results of previously completed basic research.

What is missed in that argument is recognition that an enormous amount of basic research with implications for agriculture has been, and is being, conducted throughout the world. Its findings are available for use by anyone who knows of their existence and wishes to use them. A research scientist anywhere in the world can have access to that knowledge through a good research library.

What is not available — and cannot be imported — is applied research that adapts the results of basic research to the peculiar problems of individual countries and of regions within each

country. As long as the supply of research scientists is limited, it is important that applied research take precedence over engaging in a small amount of additional basic research. Basic research may (or may not) yield results that will be useful at some unidentifiable time in the future. Applied research can be focused, from the beginning, on meeting particular needs known to be critical now.

It is only after a country has a considerable number of highly trained research scientists — perhaps more than 100 — that it may be appropriate for some of the research resources of a ministry of agriculture to be used to support basic research.

11 *Provision should be made within each country's research system to assess production technologies imported from abroad.*

This is particularly important for small countries which cannot afford a large program to meet most of their own research needs. For such countries, importing farm technologies from abroad seems an economical alternative. However, where that is done, it is important that adequate arrangements be made for assessing the appropriateness of those technologies. It needs to be recognized that such assessment is itself complicated and must be conducted by trained research scientists.

12 *Research results should be reported not only in a form appropriate to be read by other scientists but in ways that can be understood and used by extension workers, farmers, and policy-makers.*

It is characteristic of high-prestige basic research that the audience for its reports is limited to other scientists, and each discipline builds up its own specialized vocabulary that outsiders can seldom understand. [4]

Perhaps to catch some of that high prestige, reports of applied research tend to be expressed in scientific jargon.

Applied research to accelerate agricultural growth has not fulfilled its mission, however, until it has been used by action agencies and farmers to help increase farm production. Few persons in those action agencies understand the various special scientific jargons. Farmers certainly do not. Consequently, it is important that research results related to accelerating agricultural growth be made available in a form in which laymen can understand them, in addition to any other form in which they may be presented .

[4]*In fact, Jacques Casanera uses this criterion in defining basic and applied research. "Basic research," he contends, "is research to be used solely by other scientists. Applied research is research to be used by non-scientists." Comment at IADS Seminar on Defined-Area Projects, Bellagio, October 1979.*

13 *Full advantage should be taken of opportunities for on-the-job training of scientists, laboratory and field technicians, and production specialists for extension services.*

It is by doing research that one learns how to do it. That is why every Ph.D. student is required to conduct one research project before getting his degree. He must select a problem, review previous research that bears on the topic, plan the research, conduct the experiment or collect the data, analyze the results, and write a report stating his results or findings.

The same procedure can be used within research organizations by assigning an appropriate project to a junior researcher for him to carry out under the guidance of a senior researcher.

There are many other opportunities as well for on-the-job training in connection with conducting research. In many cases it is imperative to train laboratory or field technicians because otherwise none are available. In other cases, even if technicians are available, a pattern can be established of having a limited number of trainees attached to research projects in order to increase the number of trained persons available for expansion of the research program — or to fill vacancies as other employers lure away technicians for whom there is a great demand.

Each of the international agricultural research institutes has mounted substantial training programs, each of which usually includes participation in actually carrying a project through. Since shortage of research scientists is almost universal, it is well for practically every project conducted within a national research program to include a training element.

Advantage should also be taken of opportunities to use research personnel to upgrade the professional capacity of employees of other agencies, as in the program to train extension workers as rice production specialists conducted at the International Rice Research Institute (IRRI) and, with IRRI's cooperation, in individual countries.

14 *Productive agricultural research programs take full advantage of international resources.*

Prominent among those resources are the results of basic and applied research conducted throughout the world in the past, and which are now available in research reports.

The International Service for National Agricultural Research (ISNAR) concentrates wholly on cooperating with, and strengthening, national agricultural research systems.

Strengthening national agricultural research has high priority among the activities of the Food and Agricultural Organization (FAO) of the United Nations.

The international agricultural research institutes collect germplasm from all over the world to make it available to national research programs. They develop new strains for national program scientists to use in breeding work. They conduct training programs to upgrade research abilities of persons from individual countries.

In recent years the World Bank has made a number of large grants in support of national agricultural research programs.

The International Agricultural Development Service (IADS) participates in country agricultural development projects that have a strong research component.

These are only a few of the many international resources that can be tapped.

Each country needs its own agricultural research program, but it need not do the job alone. Many external sources of collaboration are available and should be used.

15 *Finally, to be productive, agricultural research programs need continuous and long-term financial support, and timely release of funds for expenditure.*

Some types of research take several years to complete. All of them require continuity. If some projects are interrupted for only a few days, they may be completely spoiled. And new problems keep emerging. New diseases are encountered. Market conditions change. One problem solved creates new ones.

Continuity is imperative, as are arrangements for timely release of funds to research agencies so that ongoing projects may not be disrupted.

Some Critical Requirements for Productive Agricultural Research

1. It must be conducted by specially trained research scientists.

2. It requires participation by research scientists, each of whom has been trained in a particular scientific discipline.

3. Each research team and each research organization needs to consist of a minimum critical mass of research scientists.

4. Any research agency needs a type of organization that encourages staff interaction.

5. Productive research requires a style of administration which emphasizes leadership more than authority.

6. Productive research requires appropriate selection of research projects.

7. Research scientists must have adequate scientific instruments, equipment, and other facilities with which to work.

8. Productive agricultural research requires a combination of experiment station research, district adaptive research, and on-farm testing.

9. Research to accelerate agricultural growth needs to include experimentation to improve rural agri-support services and research related to national policies affecting agriculture.

10. Applied rather than basic research should be stressed first.

11. Provision should be made within each country's research system to assess production technologies imported from abroad.

12. Research results should be reported in ways that can be understood and used by extension workers, farmers, and policy-makers.

13. Full advantage should be taken of opportunities for on-the-job training in research organizations.

14. Productive agricultural research programs take full advantage of international resources.

15. Productive agricultural research requires continuous and long-term financial support, and timely release of funds for expenditure.

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