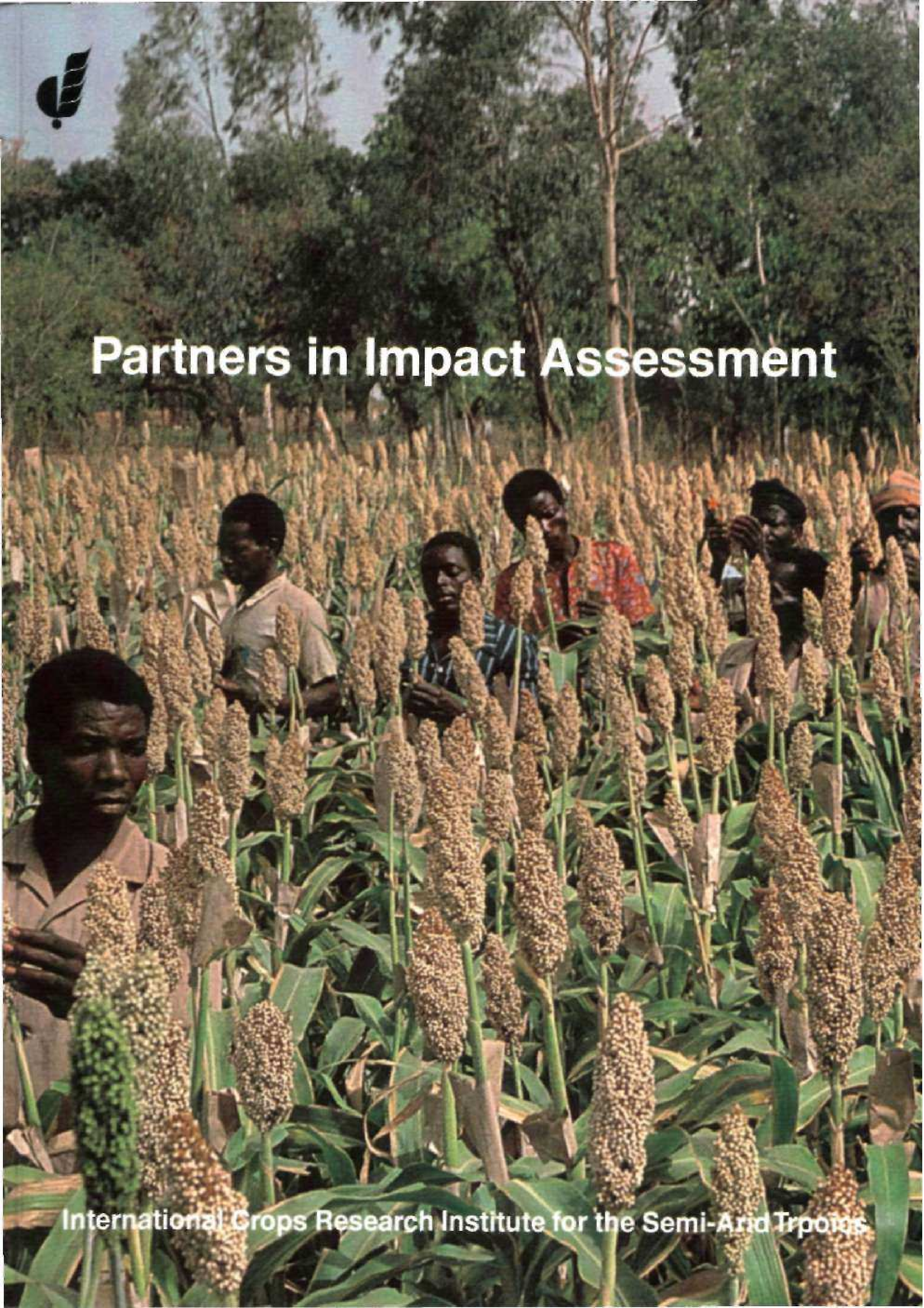

Partners in Impact Assessment

International Crops Research Institute for the Semi-Arid Tropics

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Abstract

Regional workshops were held at Sadore, Niger and Samanko, Mali, to evaluate the joint impact of ICRISAT and National Agricultural Research Systems (NARS) in Western and Central Africa. Twenty-one scientists from ICRISAT and the national program in Cameroon, Chad, and Niger participated in the workshop at Sadore. The Samako workshop was attended by 18 scientists from ICRISAT, NARS collaborators in Burkina Faso and Mali, INSAH and the West and Central African Sorghum Research Network (WCASRN). National program representatives identified specific jointly-developed technologies that should be targeted for impact assessment. Methodological approaches for measuring welfare benefits to consumers and producers were discussed and illustrated with case studies. Minimum dataset requirements were outlined and protocols for case studies on technologies targeted by NARS partners were developed

About ICRISAT

The semi-arid tropics (SAT) encompasses parts of 48 developing countries including most of India, parts of southeast Asia, a swathe across sub-Saharan Africa, much of southern and eastern Africa, and parts of Latin America. Many of these countries are among the poorest in the world. Approximately one-sixth of the world's population lives in the SAT, which is typified by unpredictable weather, limited and erratic rainfall, and nutrient-poor soils.

ICRISAT's mandate crops are sorghum, pearl millet, finger millet, chickpea, pigeonpea, and groundnut; these six crops are vital to life for the ever-increasing populations of the semi-arid tropics. ICRISAT's mission is to conduct research which can lead to enhanced sustainable production of these crops and to improved management of the limited natural resources of the SAT. ICRISAT communicates information on technologies as they are developed through workshops, networks, training, library services, and publishing.

ICRISAT was established in 1972. It is one of 16 nonprofit, research and training centers funded through the Consultative Group on International Agricultural Research (CGIAR). The CGIAR is an informal association of approximately 50 public and private sector donors; it is co-sponsored by the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP), and the World Bank.

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3-5 May 1995, Sadore, Niger
9, 11-12 mai 1995, Samanko, Mali

Edited by

J Baidu-Forson, M C S Bantilan, S K Debrah, and D D Rohrbach

ICRISAT
International Crops Research Institute for the Semi-Arid Tropics
Patancheru 502 324, Andhra Pradesh, India

1996

Participating Institutions

DRTA

Direction de la recherche et de la technologie agricole
Ministere du developpement rural, BP 441, N'djamena, Chad

DVA

Direction de la vulgarisation agricole
Ouagadougou, Burkina Faso

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Institut national de recherches agronomiques du Niger
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Institut du Sahel
BP 1530, Bamako, Mali

IRA

Institut de recherche agronomique
BP 33, Maroua, Cameroon

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Inauguration

Opening address at Sadore, Niger

J G Ryan[1]

Chairperson Dr Abdoulaye Gouro, Director General, Institut national de recherches agronomiques du Niger (INRAN), ladies and gentlemen from the national programs, and ICRISAT:

It is a real pleasure for me to be here and especially to welcome our colleagues from the national programs to this workshop. It is appropriate that we look at how we can better assess the impact of our joint work. It is very timely, because in spite of the historically high rate of return to investments in national and international agricultural research, agricultural scientists are having a difficult time convincing national finance departments and importantly the donor community, of the wisdom of further investment in agricultural research.

I think we need to look at impact assessment for two reasons. First, investments in agricultural research are dwindling in terms of resources that are available as compared to the challenges. We need to mobilize additional resources for research and prevent them from falling further. Second, measurements or assessment of impact or lack of impact need to be used to improve the internal agricultural research management in our various institutions.

The international agricultural research centers (IARCs) and the national agricultural research systems (NARS) have become closer, and this is true in Asia, Latin America, and Africa. Collaboration and the exploitation of complementaries are what we talk about when we meet to try and identify where we can best contribute individually to our joint endeavors. With the strengthening of national programs, IARCs have tended to focus on strategic research questions to complement the applied and adaptive focus of national programs. With a strategic focus, it becomes even more difficult to assess the precise impact of international agricultural research efforts. It is important that partners in the global agricultural research and development systems work together to assess joint impact, because in that way, we recognize the interdependencies amongst us and we can establish the value of continuing collaboration. I believe the donor community welcomes a joint impact assessment approach because these same donors support both international and national research.

An increasing part of the products of agricultural research is what we might call intermediate products like diagnostics, probes, parental lines, segregating materials, and management practices. Also, policy advice has legitimate socioeconomic impact although it can be difficult to assess. These intermediate products are really inputs in the final impacts and are genuine scientific contributions. Unfortunately, national governments and the donor community are not too interested in intermediate products. They want to hear about final products: Take me to the small-scale farmer and

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show me how you have made a difference to her and her husband'. As scientists, we like to think that quality science, methodologies, and publications are important parts of the work but they are no longer sufficient. We have to continue to educate our stakeholders, but it is no substitute for measures as imperfect as they might be, of more final impacts.

The criteria that we use for assessing impacts are quite varied. We will hear what economists have to say about criteria for measuring impact and I think, it is important that in looking at impact assessment, we don't limit ourselves to looking backwards, but we also look to the future. As economists like to say, we look at *ex post* and *ex ante* impact assessments so that we operationalize the measurement of impact and institutionalize it within our various organizations.

Biological and physical scientists often lament the idea that we have to transform scientific knowledge into dollars and franc CFA effects. It is terribly important that social scientists work directly with biological and physical scientists to educate each other about their joint contributions. The donor community and finance departments like to look at benefit/cost ratios, and employment when they consider the wisdom of investing in agricultural research, compared with alternate investments.

The other lament I hear from biological and physical scientists is 'with all this priority setting and impact assessment economists talk about, scientific serendipity is stifled'. What we are trying to do is to maximize and measure the impact. It is not to stifle serendipitous findings, but to ensure they occur in areas where impact is the greatest. That is the relationship between priority setting, impact assessment, and allowing scientists to pursue their ideas.

You will hear a lot this week about more formal ways to go about assessing impact and I do not think that all impact assessments could, or should, be formal. Even informal impact assessment can guide us in setting future directions for research. We do not want only final figures of benefit/cost ratios, but also to understand why precisely the ratio happens to be small or large. This type of information is equally important in linking *ex post* impact assessment with *ex ante* priority setting.

Some areas of work are easier to assess than others. You all are aware of the urgency of research that looks at the problems of natural resource management. We would only acknowledge that it is extremely difficult to assess in economic terms, the likely or past benefits from research aimed at sustaining the natural resource base. Crop improvement research, in many ways, is an easier candidate for impact assessment, and that is probably why you will hear a lot about it this week. Many donors and governments are urging us to get more involved in sustainability research, and a few years later, we will be asked to show what our impact has been in that area. As an example, we have to look at how to measure the benefits of soil erosion research, nutrient dynamics research, and topics relevant to this environment. It is not as easy as assessing the impact of new varieties or hybrids of the staple food crops.

Also, we need to look at the impact of training. How do we assess the upgrading of national scientific capacity that has occurred over the last 20 years in sub-Saharan Africa? Twenty years ago, in many countries of western Africa, it was not easy to find someone with a PhD. That is not true today. How do we assess the economic value of training in terms that will be understood, and convince the donor community that it is a worthwhile area of investment?

Socioeconomics research is another difficult area to assess. Economists are always embarrassed by the fact that though we can help assess the impact of plant breeding and hopefully natural resources management research, we do not do a very good job of assessing the impact of economics and policy research.

In both *ex ante* and *ex post* impact assessment, we have to recognize that agricultural research has many goals that it is trying to achieve and the measures of impact have to recognize those multiple goals. In impact assessment, we also must ensure that we have peer review. There is a danger if we only assess our impact within our institutions. Stakeholders who are looking at those assessments will wonder whether there is not some inherent bias in favor of the institution.

At ICRISAT, in our Medium Term Plan (MTP), we used four basic criteria to try and assess the relative priority we might accord to different themes of research: efficiency, equity, sustainability and internationality. In setting up our research portfolio, we set milestones within the protocols in the research themes - 110 in our MTP - so that we could make judgements about how well we were succeeding in reaching the various milestones. We believe this is a useful way to link *ex ante* priority setting with *ex post* impact assessment where similar criteria are used in both.

One project that emerged out of the MPT is dedicated to research evaluation and impact assessment. This project is trying to see how we can institutionalize the information that we assemble from the MTP with measures of impact of an *ex post* character. So, we have a database that can assist us, NARS, and donors to make more informed judgements about the investments in research. We have to provide our stakeholders, like the treasuries, the finance departments, and the donor community, with information that justifies past and future investments in agricultural research.

The need for impact assessment is being increasingly realized. The United States Agency for International Development (USAID) is undertaking a series of studies in Africa to assess the payoff of its investments in agricultural research. An impact assessment was conducted of the Sorghum and Millet Improvement Program that ICRISAT has been undertaking in association with the Southern African Development Community (SADC) on behalf of the Southern African Centre for Cooperation in Agricultural Research (SACCAR). The national program of Niger, INRAN had a recent mid-term review, where I am sure issues related to impact were also part of the exercise. The Consultative Group on International Agricultural Research (CGIAR) is giving an increased profile to impact assessment by creating an independent unit within the CGIAR to continuously monitor this important area.

In conclusion, let me say a few things about some misnomers in impact assessment. I often hear scientists who are working on an individual commodity say 'the area grown of a particular crop is declining. This is not good, I am a sorghum breeder or a millet breeder and my job is to increase the area of those crops otherwise I am not having impact'. The changes in the area grown of a particular crop are not accurate indexes of impact or lack of impact. You can have a situation where the area of a crop is declining in the region, however production stays the same because yields have risen. In the short term, if demand is not shifting greatly you would expect declines in the area sown to the crop or the amount of labor that is expended on that crop because of technological changes affecting yields. Indeed, the mechanism of generating economic impact can often be the saving of resources like land and labor, that are freed up to do other more profitable things than grow the crop of interest. That is how economic growth occurs. So, declining area in some crops, far from being an indicator of failure of research, can possibly be an indicator of success. This is why we need to talk about methodologies. We need to understand how to go about it properly because you can use the wrong indicators in impact assessment.

A second important factor to be aware of is that changes in yields, particularly yields per hectare in an environment like Africa, are not always the best measures of success or failure, especially if you look at national aggregate yield trends. The element that is really important to an economist in assessing impact is determining additional costs that have been required over and above the extension and research costs to achieve those increased yields. Costs per tonne are the best indicators of potential impact rather than yields per hectare, changes in yields per hectare, or changes in yields per person. We must look at the other investments that went into the yield effects as well as the pure research and pure extension input.

There can also be a situation of declining yields, where research is having impact if yields have declined without maintenance research. We had dramatic yield increases in Asia that have tended to plateau and began to decline in some areas. Some would argue that research has now failed, however, this is not necessarily true. We must ask the question, if research did not continue, would yields have reached a plateau earlier, or would they have actually declined? Thus, a benefit of research is the prevention of further decline in yields, so we must be alert to creative ways of conveying that message.

Another important ingredient in impact is reducing what I call semi-variance. A lot of the research on the crops of interest to the national programs and ICRISAT, like sorghum, millet, groundnut, cowpea, and other crops in rainfed agriculture, have widely fluctuating yields. We are trying to look at the yield-reducing factors or the yield-varying factors like drought, pests, and diseases. Reducing the variability of yields has a measurable economic impact and takes some skill to measure.

I have gone on too long because this is something I enjoy talking about and working on, but others who are closer to this topic than I, will do a far better job in elaborating some of these ideas. I hope the outputs of this workshop will include a better sense of the methodologies we might bring to address some of the issues raised, and case studies suitable for evaluating joint impact.

Thank you very much.

Opening address at Samanko, Mali

D D Rohrbach[1]

Director General of the Institut d'economie rurale, Dr Oumar Niangado, colleagues from agricultural research programs in Burkina Faso, Mali, and ICRISAT:

I take this opportunity to review briefly why impact assessments have become increasingly necessary to justify the funding of agricultural research programs. I would also like to argue that when imaginatively employed, impact assessments can become valuable tools for research management. We need to calculate rates of return for past research, but we also need to consider how a wider range of impact indicators can be used to target future research. Finally, I propose that the assessment of research impact needs to become a continuous process wherein the evolution of technological change in the agricultural sector is monitored and the targets for future investment are periodically re-examined.

Government and donor requests for formal assessments of the impact of agricultural research are principally motivated by the current scarcity of investment resources. National budget deficits create demands for stronger justification for research funding. Such allocations compete directly with spending on alternative programs for employment creation and economic growth. Investment returns must match the high costs of public borrowing to finance budget deficits.

Many international donors have also stopped to question the relative returns to research funding. I recently spoke with a group of American journalists who were touring Africa in search of a few success stories of agricultural development. They noted that American taxpayers share a common perception that there has been no agricultural development on this continent. Despite the allocation of billions of dollars of American money to agricultural research and development, per capita food production continues to decline. Average yields remain low. Requests for food aid appear unending. Many Americans correspondingly argue that only the elimination of donor assistance will focus attention on the need to invest scarce funds more efficiently.

In addition, assessments of research impact are necessary to challenge research scientists to contribute more directly to technology adoption. How many times have we heard the suggestion that:

- 'With another season of data', or
- 'With another commitment of funding', or
- 'If extension does its job', or
- 'If the seed gets multiplied'.

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Scientists need to encourage the release of new technologies. We also need to ask what are the costs of not releasing a new variety or offering a new management practice which may improve production productivity. What are the costs of withholding technological options from farmers?

Impact assessments are most commonly promoted as a means to encourage greater investment in agricultural research. This involves the conduct of *ex post* assessments of known successes. We identify those technologies that have been widely adopted and argue that the returns to investments made in their development are indicative of the returns to similar sorts of research; or offset the full costs of the wider research program. Analyses proving the existence of large benefits to past research investments provide a means to assure governments and donors that agricultural research can offer competitive rates of return. Impact assessments can, thus, encourage the mainte--nance and even the expansion of research funding. In addition, impact assessments can offer a means to distinguish areas of research or research targets promising different levels of return in the future. This requires estimation of the potential benefits to be derived from a wide range of alternative investments in breeding, crop or livestock management, plant protection, and even economics. Research proposals offering the prospect of higher rates of return may be targeted for greater funding. Those offering limited returns may be dropped from the research portfolio. Therefore, *ex ante* assessments can help research managers target the allocation of resources to increase future rates of return.

Impact assessments can also facilitate the diagnosis of constraints to technology adoption. Scientists often argue that policy and institutional constraints limit the adoption of technologies. If adoption constraints are binding, funding for additional research may no longer be justified. The technology is inappropriate and the research investment has offered a negative return. Often, however, we simply fail to diagnose the adoption constraints or they are diagnosed incorrectly. Further, more incentives to resolve the constraints are limited by institutional boundaries between research and extension. A greater involvement of scientists in identifying the causes of adoption constraints and implementing strategies for their resolution is needed. One of the greatest constraints to the impact of agricultural research in western and central Africa is the lack of adequate facilities for seed multiplication and dissemination. It is difficult to justify continued funding for crop breeding programs unless this constraint is resolved. Assessments of potential returns to breeding efforts can help rationalize complementary investments in seed multiplication to assure the realization of expected returns. However, breeders need to take greater responsibility for providing training and technical support in seed production.

Impact assessments can help identify more opportunities for exploiting research spillovers. By tracing the varied and extensive contributions to the development of past technology, impact assessments can highlight patterns of research spillover. In this period of funding constraints, we should be consistently seeking to better exploit such opportunities. Impact assessments can help us identify how we can complement one another's efforts to assure higher investment returns.

When conducting impact assessments, we need to consider a range of impact indicators in addition to rates of return. Publicly funded research, in particular, has an obligation to pursue welfare gains which are difficult to capture in simple investment models. These include distributive gains, whereby improvements in productivity of the poorest and most food-insecure segments may be valued more than productivity improvements among wealthier farmers. Economic theory is currently grappling with the demand for improved measures of sustainability. Such assessments are complicated by the shifting value attached to environmental resources and the different value attached to such resources by different segments of each country's population. Donors are increasingly concerned with the differential impacts of their investments on gender. Some donors prefer to direct their investments toward research more likely to benefit women. Many want to be assured, at least, that new technologies do not worsen the welfare of women. We cannot simply assume that the area sown with a new variety or average yield is an adequate measure of impact. In some cases, improvements in productivity may lead to a reduction in the area that is sown. For example, improvements in sorghum yields may allow farmers to meet household food requirements with a smaller sorghum area. Land and labor resources may then be reallocated to another crop. Similarly, farmers may adopt varieties offering valued traits other than improved yield. Early maturity may offer flexibility in the cropping system or a distribution of the labor profile. Varieties may be accepted for processing ease, greater storage, or grain taste. Varieties may be chosen because they offer crop residues which are more palatable to animals. Thicker stems may offer stronger building material. In effect, the simple investment model based on yield gains and the area of adoption may fail to measure some of the most important values of research investments.

The scarcity of research resources also argues for occasional reappraisal of the return to alternative investments. An initial set of variety releases may offer the prospect of favorable returns while the next set may offer yield gains that are only marginally better. The adoption of improved cultivars may then justify greater investment in agronomic research necessary to exploit the potential productivity of a new variety. This provides justification for shifting a portion of research resources away from plant breeding toward agronomic research. Recognition of shifting pest pressures may also justify a reallocation of research funds towards or away from plant protection work. On a broader scale, technological change offers new avenues for economic growth. New policy and institutional constraints become binding and new justifications arise for resolving them. Finally, impact assessments offer excellent means to help scientists and the research service to publicize their successes. Such publicity encourages renewed research effort. This also facilitates the development of a broader constituency of support for larger and longer-term research investments.

In sum, impact assessments have become a necessary means to justify research budgets in an environment of limited investment resources. They offer a valuable guide to the allocation of future research investments toward areas of higher return. Used imaginatively, assessments can diagnose constraints to impact and improve the efficiency of research management. If successful, we can shift the focus of debate on research impact from the question of returns to past investments to the consideration of optimal levels of future investment. Rather than having to justify past work, we can concentrate on the pursuit of greater impacts in the future.

Rationale for a joint ICRISAT/NARS impact assessment workshop in western and central Africa

M C S Bantilan[1]

Effective partnership is evolving among the national agricultural research systems (NARS) and international agricultural research centers (IARCs) in the global agricultural research and development system. The NARS are becoming stronger and are increasingly involved in productive collaboration with the international research community. ICRISAT, like other IARCs, is guided by a research policy aimed at concentrating on areas of research where it has comparative advantage. The emphasis is to complement the efforts of our partners in national programs.

ICRISAT's mix of strategic and applied research is responding to the needs of its national program partners according to their research strengths. In locations where NARS are hampered by several constraints, research efforts have concentrated on applied and adaptive research leading to the development of location- and constraint-specific final products. In contrast, where NARS are strong and the seed sector is rapidly growing, ICRISAT has shifted its emphasis to strategic and upstream research which produce intermediate outputs - parental lines, segregating materials, methods, screening techniques, and management practices, among others. The intermediate products serve as inputs to further research which generate improved products that farmers can use directly.

As research partnerships are developing between ICRISAT and NARS in western and central Africa, there is also a growing common interest in research evaluation and impact assessment. With shrinking budgets for agricultural research and donors demanding impact in farmers' fields, national programs face the same challenges of setting research priorities, optimally allocating research resources, and evaluating research impact.

As ICRISAT and NARS undertake research evaluation efforts, interaction is important to facilitate a continuing exchange of information on approaches, methodologies, and databases. It is expected that emphasis in approaches will evolve, reflecting the unique features and requirements of each country and/or institution, and the continuing interactions will greatly benefit each institution's research evaluation efforts.

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Overview of workshop and expected outcomes

J Baidu-Forson[1]

This overview begins with preliminary observations on two important questions and concepts related to the theme of the workshop. First, what are the products of research? Let me suggest that these comprise both tangible and intangible outputs generated by scientific research. Tangible research products, such as varieties and pesticides, are physically visible, in contrast to intangible research outputs, such as information, which have no physical forms. Now for my second question. What is meant by impact of research? I would like to propose that impact of research deals with the welfare effects of research outcomes or products on producers, consumers, beneficiary research systems, and private or public sector organizations. With these clarifications, I will outline the three objectives to be achieved by this impact assessment workshop:

- Identify and share information about priority technologies that should be targeted for evaluation to show joint impact of research conducted by ICRISAT and NARS,
- Review methodological approaches relevant to the evaluation of the impact of research and extension, and
- Prepare workplans and protocols for selected priority technologies jointly targeted for impact assessment.

General overviews and presentations by NARS on target technologies for joint impact assessment will be made on the first day. Methodological reviews are scheduled for the second day, to set the stage for NARS-driven protocols or workplans that will be developed on the third and last day of the workshop. Based on these objectives, the expected outcomes at the end of the workshop are:

- Identification of ICRISAT/NARS priority target technologies that should be evaluated and jointly developed,
- NARS-driven protocols describing research activities in specific locations,
- Work schedules and their distribution among collaborating scientists,
- Budget outlines, and
- Expected product(s) of the joint research.

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Presentations to Identify Case Studies

Overview of genetic enhancement technologies for impact assessment in western Africa

K Anand Kumar[1], D S Murty[2], B R Ntare[3]. S N Lohani[2], and S C Gupta[3]

The three mandate crops of ICRISAT of relevance in the Western and Central Africa (WCA) region - sorghum, pearl millet, and groundnut - occupy an estimated 24.4 million ha. Pearl millet is cultivated on close to 50% of the area, sorghum on 39%, and groundnut on 11%. A total production of 16.6 million tonnes is comprised of over 45% from pearl millet; 40% from sorghum; and nearly 14% from groundnut. Several varieties produced by earlier breeding research are used by farmers, though to a limited extent in some cases.

Data suggest that adoption of new varieties varies from 2% to 10% of the national crop area. Some of the factors that contribute to lower than expected levels of adoption are; improved cultivars do not respond to farmers' objectives, improved management techniques of improved cultivars are limited, and a lack of an effective seed multiplication and distribution service.

ICRISAT-NARS varieties are at different research and extension stages: advanced on-station trials; on-farrn tests; pre-release; released; or grown by farmers. Recommendations for ICRISAT-NARS impact assessments for 1995/96 include sorghum variety S 35 in Cameroon and in Chad; pearl millet varieties GB 8735 and ITMV 8001 in Chad; IKMP 1 and IKMV 8201 in Burkina Faso; Toroniou, ICMV IS 88102, and SOSAT-C88 in Mali; and IBMV 8001 and IBMV 8004 in Senegal.

In recent years, ICRISAT has enlarged its presence in WCA. Collaboration and partnerships with NARS, international institutions, and crop networks are evolving to capitalize on complementarities. ICRISAT collaborates with national programs and networks by providing seed of improved material, furnishing multilocational and regional trials, and conducting joint research. Seed production capabilities differ between countries in the region. ICRISAT's involvement in providing training and technical support in seed production is essential, and the success of seed production depends on the relationship between research and extension services. Increasingly, the private sector is showing interest in production and distribution of seeds of ICRISAT's mandate crops.

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Overview of resource management technology targets for impact assessment in western and central Africa

S V R Shetty[1], A Bationo[3], and M V K Sivakumar[2]

The goal of resource management research is to contribute towards achieving sustainable food security. It has the dual role of increasing productivity while at the same time protecting the environment. The products of resource management research are principles, processes, and methodologies. Unlike seed-centered technologies, the products are location-specific.

A considerable body of knowledge about sustainable management of resources and improving systems productivity exists in western Africa. These technological options include:

- Soil moisture conservation through tillage, conditional farming, appropriate crop management, and use of water harvesting techniques,
- Erosion prevention and control through mulch farming, conservation tillage, vegetative hedges, contour bunds, and windbreaks,
- Soil fertility improvement through the use of organic amendments, biological nitrogen fixation, chemical fertilizers, and agronomic practices related to fertilizer placement and timing of application to increase fertilizer use efficiency, and
- Utilization of appropriate cropping systems through cultivars suitable for intercropping, crop rotation, and agroforestry systems.

Research has shown that the productivity of cropping systems can be improved substantially. However, technology design lacking consideration of users perceptions and resources, and policies have impeded widespread adoption.

Some potential target areas where adoption of technologies have been reported and where joint impact assessment could be undertaken are:

- Soil fertility improvement in Gobery, Niger.
- Soil and water conservation in Yatenga, Burkina Faso and Keita, Niger.
- Intercropping systems in Mali (millet/maize) and in Niger (millet/cowpea).
- Crop rotations in southern Mali.
- Animal traction in southern Mali.
- Agroforestry in the Maggia Valley, Niger, and in the millet/groundnut basin in Senegal.

1. Agronomy Division, 2. Soils and Agroclimatology Division, ICRISAT Western and Central Africa Region, and 3. International Fertilizer Development Center (IFDC), ICRISAT Sahelian Center, BP 12404, Niamey, Niger.

- Institutional strengthening and infrastructure development in selected countries, such as the USAID/ICRISAT special project with the Institut d'economie rurale (IER) in Mali.

The location-specific nature of resource management technologies, the time frame, and the conditions necessary for their large-scale adoption should be taken into consideration in impact assessment. The use of simulation modelling also needs to be considered to assess the potential impact of promising technologies. Future adaptive research and development programs at the local level should involve farmers, extension agents, non-governmental organizations, and policy makers to design, implement, and evaluate appropriate technologies.

Country Presentations

Development and testing of S 35 in semi-arid regions of Cameroon

R Kenga and A Adamou[1]

Crop failure and low yield caused by insufficient rainfall, have resulted in foodgrain deficits in western and central Africa. Plant breeding programs have been initiated with the hope that levels of food production would increase through rapid selection and adoption of improved cultivars. Breeding strategies included the introduction of exotic lines for direct and indirect use and hybridization to generate new cultivars. Selection criteria were: 90-115 days maturity cycle; high and stable grain yield; resistance to disease, particularly *Striga hermonthica;* good grain quality; and farmers' preferences.

In 1982, hundreds of lines were introduced and screened. Sorghum variety M91019-6 was reselected, and after two cycles of mass selection, the ensuing variety was named S 35. It was tested in on-farm trials over a 4-year period at 7-10 locations per year.

On-farm testing of improved sorghum cultivars in the semi-arid region of northern Cameroon was emphasized as both research and extension sought to introduce improved cultivars and accelerate their adoption. The on-farm tests were conducted mostly in the northern and central regions of the northern part of Cameroon, where sorghum is cultivated by approximately 250,000 farming families and covers an area of roughly 350,000 ha. The relative performance of S 35 was best during the severe drought that occurred in 1984. As a result, a seed multiplication project produced over 20 t of seed and the Societe de developpement du coton (SODECOTON), a cotton development company, began extension on 650 ha.

In an attempt to verify the percentage of adoption of S 35, a survey was carried out by the on-farm testing unit at the Institut de recherche agronomique (IRA) located in Maroua. With the assistance of SODECOTON extension staff, 211 farmers were interviewed on their farms where S 35 was grown. Farmers who adopted S 35 had the following characteristics as compared to non-adopters: smaller area cultivated to postrainy season sorghum; larger person-equivalent household size; and S 35 had been grown since 1985.

In 1990, a second region-wide survey was conducted to evaluate the extent of adoption. The largest absolute number and percentage (24%) of sampled farmers adopting S 35 was in the Maroua region. Tchatibali, Guider, and Kaele were the other regions where S 35 adoption was noted. These four regions may therefore be targeted for impact assessment of the adoption of S 35 on the welfare of farmers in northern Cameroon.

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Identification of varieties for impact assessment in Chad

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The research stations at Gassi and Bebedja in Chad perform variety improvement tests and distribute millet, sorghum, and groundnut varieties from regional and international research organizations, such as ICRISAT, the International Institute of Tropical Agriculture (IITA) and the Semi-Arid Food Grain Research and Development (SAFGRAD). Between 1990 and 1991, the following ICRISAT varieties were introduced in farmers' fields:

- Sorghum S 35,
- Pearl millet ITMV 8001, GB 8735, ICMV IS 85327, and ICMV 85333,
- Groundnut ICG(GS) 57, JL 24, ICG(E) 13, and ICG(E) 55.

Promising varieties are sent to farmers for testing and feedback. This collaboration with international institutions enabled us to identify sorghum, millet, and groundnut varieties that performed better than the local ones. Sorghum variety S 35 was appreciated for its taste, grain color, plant height, and the value of its stem as animal fodder. Pearl millet varieties GB 8735 and ITMV 8001 were also introduced to to farmers. GB 8735 was appreciated for its short stem, early maturity (59% mature in 57-68 days), drought resistance, grain filling and size, and especially its sweet taste when prepared as a local porridge. ITMV 8001 (50% mature in 70-72 days) has a light yellow grain color, and farmers especially appreciated its lanceolate head.

After a variety is selected by farmers, breeder seed G_0 and G_1 are multiplied on the research station. In cooperation with the research station, the seed center assures multiplication of breeder seed G_2 to G_5. R_1 seed produced by breeders is then returned to seed farms for reproduction. Distribution of seed is done by NGOs and the Office national du developpement rural (ONDR). The national program introduced the sale of 'mini-doses' of seed, weighing 0.25 to 3 kg, to overcome difficulties associated with seed distribution. These 'mini-doses' of seed help to reach a larger number of farmers. To avoid the risk of pollen contamination by other varieties, seed from such cross-pollinated species as pearl millet must be renewed at least every 2 to 3 years.

We propose that sorghum variety S 35 be targeted for impact assessment on account of its widespread adoption by farmers in Chad.

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Impact assessment of INRAN investment in pearl millet, sorghum, and cowpea

J Naino, S Ly, and S Aboubacar[1]

The Institut national de recherches agronomiques du Niger (INRAN) uses the approach of purifying landraces to attain its goal of quickly developing productive varieties adapted to the production conditions of small-scale farmers. Some of the most cultivated landraces of Niger were purified at INRAN research stations. The trials permitted us to note that some 'variety-populations' could be introduced in areas other than where they originated (i.e., ZA-P1 in the Kollo region and DG-P1 in the Bengou, Tarna, and Kollo regions).

A study was conducted in 1992 to assess profitability of investments in research and transfer of technologies applicable to pearl millet, sorghum, and cowpea. The model of economic surplus was measured. Furthermore, the objective of the study was to analyze the main institutional factors that influenced the development and adoption of technologies.

Adoption coefficients and the slope of supply curve were assumed because of data constraints. For this reason, sensitivity analyses were conducted. Returns the investment in research and extension were assessed on the basis of 12 hypotheses. From the analyses, it was deduced that the returns to research and technology transfer of pearl millet, sorghum, and cowpea varied between 2% and 21%. The most realistic rate was 10%.

Three conclusions were reached as a result of this study:

- The adoption rate has a large effect on the returns to investment. Contacts between scientists, extension agents, and farmers need to be reinforced,
- Cowpea variety TN5-78 could have a significant impact on the returns to research if it is adopted, and
- Initial capital costs greatly reduce the return to investments in research and transfer of technologies.

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Impact assessment of on-farm trials conducted at the Cinzana Research Station

D Sanogo[1] and B Teme[2]

Since its creation in 1983, the Cinzana Research Station has developed important technologies in the areas of varietal improvement, cropping systems, and crop protection. To determine the effect of these technologies on the living conditions of farmers, the Institut d'economie rurale (IER) conducted an impact assessment of the Cinzana Research Station with respect to agronomic, socioeconomic, and environmental impacts. The specific plan of work consisted of conducting inventories of technologies adopted and determining the levels of adoption of: 1. improved varieties of cereals and legumes introduced in the agroecological zones of the region; 2. use of improved cultural practices such as organic fertilizers; 3. millet/cowpea intercrop by farmers for soil fertility and yield; and 4. strategies used by farmers to control major pearl millet diseases.

Surveys were conducted in 12 selected villages in the Cinzana district (Central Segou, Sanado, Markala and Tamani). Classified according to agroecological zones, 74 Agricultural Production Units (UPA) were covered by the study. They conducted 36 tests of which 24 were on varietal improvement, 6 on improved practices, 4 on Apron Plus®, and 2 on agroforestry hedgerows. Levels of adoption were estimated and views on the innovations adopted were elicited.

The most cultivated improved millet varieties in the survey zone were Toroniou C1, improved Souna, and Benkadi-nio. Among the 21 farmers that used Toroniou, 11 continued to use it. Benkadi-nio was used at Tissala where 10 out of the 82 farmers were still using it. The rate of rejection of these varieties is 66% for improved Souna, 48% for Toroniou, and 33% for Benkadi-nio. The early maturity of improved Souna and hence its risk of bird damage contributed to its declining rate of adoption. The adoption rates were 50% for Toroniou C1, 30% for improved Souna, and 20% for Benkadi-nio.

For early cowpea, KN 1 and Gorom-Gorom were the varieties covered by the study. Within the sample frame, adoption rate was 35% (6 users out of a sample of 17) for KN 1 and 30% (4 users out of a sample of 13) for Gorom-Gorom. Globally, the rate of adoption within the study area is about 9% for KN 1 and 10% for Gorom-Gorom. Farmers are quite reticent about using KN 1 and Gorom-Gorom because of problems of seed supply and phytosanitary treatment requirements. According to farmers, these improved varieties are quite sensitive to insect attacks and require considerable control measures to conserve the seeds and treat the young plants.

With respect to improved sorghum varieties, the study covered CE 151 and CSM 219E. CE 151 was adopted by farmers at a rate of 36% (4 users out of a sample of 11).

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The reason advanced was that organoleptic qualities of this variety are not consistent with farmers' taste. Sorghum variety CSM 219E was adopted only at Kondogola.

The acceptance of pearl millet/cowpea intercropping which requires a change in cultural practice is much slower. Based on a small sample, a pearl millet/cowpea intercrop in alternate row arrangement was found to be in use in 8 of the 12 villages. About 62% of the farmers (8 farmers out of a sample of 13) are still using this cultural practice. However, the global adoption rate of the practice is very poor (3.6% of UPAs). Some 38% of the farmers stated that they used the practice at least once and later abandoned it. The main reasons for abandoning its use were lower millet plant density and problems related to commercial outlets for cowpea.

The study showed some constraints which, if not considered in the implementation of practices, will slow down, stop, or lead to rejection of technologies (constraints of production systems, outlets, and consumption behavior). However, Apron Plus®, Toroniou and Benkadi-nio seem to be promising innovations. For example, 75% of the UPAs use Apron Plus® in seed treatments.

The study of the impact of the Cinzana Station on farmers, despite the problems it encountered, produced significant results.

Presentations on Methodologies

Research evaluation and impact assessment: framework

M C S Bantilan[1]

This paper presents an overall framework in considering the research-adoption-impact continuum in the process of research evaluation and impact assessment. It traces the process of research, its output and impact on the welfare of society, and identifies the basic parameters which should come into play in assessing the impact of research. It forms the basis for the procedures and data base for agricultural research evaluation. The focus of analysis - the recommendation domain for research - should be clearly identified. The target of enquiry may be an agroecological zone, a production system(s), or a particular sector. Focus identification is crucial as this determines the scope of enquiry and evaluation.

Framework for research evaluation

The research, development, and adoption process provides a guide to identifying the set of inter-relationships that should be considered in developing a systematic information system to support research planning.

Tracing the different components of the research process, its output and logical consequences, the conceptualization of the framework starts with the consideration of investments that fund the implementation of research projects. The new knowledge and/or technology generated is expected to bring forth changes on the production and consumption environment as more or improved products become available in the market as a result of the utilization of the improved technology. To be specific, the application of science-based technologies in agriculture is expected to bring about increases in crop yields, bigger seeds, higher fodder yield, sustained fertility, or reduced soil erosion, among others. Research is also expected to improve the efficiency of various inputs including management. Ultimately, the changes in the production and consumption environment are translated into welfare gains to society.

Before the final benefits of research accrue to the members of society (i.e., producers and consumers), two important conditions must be met. First, the research undertaken must be successful in achieving its targeted objectives. This introduces the notion of probability of success or relative research capability. Second, the potential increase in production promised by a new technology is ultimately achieved only when the technology is adopted and utilized by farmers. This condition necessitates the consideration of the rates of technology adoption and the factors constraining it. However, the measurement of the welfare gain to society is incomplete if it does not take into account the externalities which the technology involves.

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The externality consideration may either be negative or positive. Classic examples of a negative externality are the human-induced soil erosion in agriculture, and the detrimental effects of chemical-based technology. The positive externalities are incorporated within the framework via consideration of spillover effects. Three types of spillover effects are considered. The first type involves the across-location spillovers, wherein a technology developed at a specific location can be adapted to improve the production efficiency of the same product at other locations (geopolitical or agroecological).

The second type of spillover effect refers to the across-commodity applicability of the technology that is developed. For example, a cultural management technique developed specifically for sorghum production may also potentially improve the efficiency of production of pearl millet and other cereal grains.

A third type of spillover effect is the indirect or price spillover effect. Because technological change for a particular commodity at a specific location brings forth increased supply, which may cause price changes, the price effect on other locations (if the commodities are traded), or its price effect on related commodities may have significance. This is particularly relevant when the elasticities of the product demand are relatively small and/or the rate of product transformation among commodities is significant.

Another factor which can influence welfare gains due to research is government policy. Policies influence the production and consumption of a commodity, or inputs used to produce it. They can influence both the benefits flowing from research and the distribution of these benefits.

The welfare effects can vary significantly among research efforts, regions, and commodities. Choices among research options are likely to be influenced by the magnitude and distribution of these effects. Which ones are important requires clarification. For example, if two regions are part of one country and if the total national welfare gain is the objective of the research institutions, then a measure of the research impact of this objective is provided by adding all the gains (or losses) of all sectors. If, however, the objective is to maximize gains to poor farmers only, the indicated subset of welfare changes is added to give a measure of how well the research option may satisfy this objective. Estimates of these welfare changes, if quantified, can be summarized in a form suitable to assist decision-makers in setting research priorities or other allocation decisions. Other aspects for consideration are: 1. effect on income distribution and poverty; 2. food security; 3. human capital development; 4. institution building and strengthening of national programs; 4. sustainability and environmental impact; and 6. implications on policy change.

Approaches to measurement

This section features the central role of economic theory in integrating technical information with secondary or elicited data in evolving measures reflecting benefits gained from research investments.

The estimation of welfare gains from the use of the new technology has usually been based on two measures. The first measure estimates the expected change in output due to research. The second measure estimates research benefits by applying the principle of economic surplus to obtain the size and distributional consequences of research-induced technological change. Both approaches utilize the basic concepts of demand and supply to represent the production and consumption environment. Substantial differences may occur between these measures. Consideration of stability of estimates under uncertain demand and supply conditions favor the use of the second measure. A good understanding of the underlying production and consumption environment is useful in choosing the appropriate measure and in interpreting the estimates.

The total benefit from research comprises of the string of benefits over the period of years the technology is utilized, net of the research investments and other costs involved in the use of the new technology. The magnitude of the welfare gain in each year is obtained by taking into account the extent to which the technology is adopted by farmers.

Refinements to this approach involve expanding the framework to incorporate multiregional trade, probability of success (in the case of *ex ante* assessment), government intervention, and potential areas for spillover effects of research across locations and commodities.

Basic model and minimum data requirements for economic impact: assessment of research

M C S Bantilan[1]

This paper presents a model for economic assessment of research benefits and the basic data requirements for assessing economic impact.

Economic surplus concept and basic model

Measurement of benefits from agricultural research uses the concept of economic surplus. The total annual benefit is measured as the sum of changes in the surplus or welfare gains to consumers and producers.

The consumer surplus is a measure of welfare represented by the difference between what consumers actually pay, and what they would have been willing to pay for marginal units of the commodity up to the amount actually purchased. Using consumer demand as a reference point, this measure of welfare is represented by the area above the price line below the demand curve. The concept of producer surplus is analogous to that of consumer surplus. Producer surplus represents the difference between the market price producers receive and the price at which they are willing to sell marginal units of their produce up to the amount actually sold. Using producer supply as a point of reference, the total welfare the producer gains is measured as the area below the price line above the supply curve.

Both surpluses are expected to change following a supply shift due to technological change. With most improved technologies, consumers' welfare improves through commodity consumption of a larger quantity at a lower price. Similarly, improved technologies increase the economic welfare of producers through enhanced productivity of available resources or reduction in the cost per unit of output.

Total research benefits is measured as the sum of the changes in the net welfare or surpluses accruing to consumers and producers. The simplest model applied in measuring research benefits is the single period static model with parallel shift in the supply function where surpluses are compared in a 'with research' and 'without research' situation. This procedure for assessing the welfare gains from research is usually referred to as the simple non-traded goods research evaluation model. As the technology brings about increased productivity or reduction in production unit cost, the supply curve is assumed to shift rightward to the right.

Benefits from research do not accrue immediately; two types of lags may be involved; the Research and Development (R&D) lag, and the technology

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availability lag. The R&D lag is the time taken from the onset of research to achievement of research objectives. This covers the continuum from basic, strategic, applied, and adaptive research. Taking the example of seed-based technologies, it counts the number of years needed to develop an improved variety or hybrid, and to conduct the multilocational trials and on-farm tests leading to a new improved cultivar. The second lag, i.e., the technology availability lag, covers the time it takes to have an identified cultivar released by authorized agencies, the lags in seed production, multiplication, processing, and distribution through the seed sector, and the delays that may be faced in introducing the new technology through the extension network.

Once technology from research is produced, it benefits society according to the extent to which farmers adopt the technology. The magnitude of the welfare gain in each year is obtained by taking into account the extent and pattern of adoption by farmers over some time horizon. Thus, the total benefit from research comprises the totality of the string of benefits over the period of years the technology is utilized, net of the research investments and other costs involved in the use of the new technology. Refinements to the basic model expands this simple approach to incorporate multiregional trade, government intervention, and spillover effects of research across other locations and other commodities.

Basic parameters and data requirements

Based on the model described above, the basic information required for economic evaluation of research impact are listed below. First, a brief description of the research process is normally useful. This provides an understanding of research objectives, expected outputs, technology features, and performance. Second, the target or recommendation domain for the technology is to be identified, that is, regions or production systems, as well as other relevant features of the recommendation domain (e.g., agroecological zones, soil type, length of growing period). This step provides a clearer identification of research focus. Third, the basic data set consists of:

a. production levels in target area
b. commodity price
c. research lags (time between research start and year when technology is made available to farmers). This may be estimated from the following data:
   i. year research started
      period of basic research (years)
      period of applied research (years)
      period of adaptive research including on-station and on-farm testing (years)
   ii. year technology is made available to farmers
   iii. for cultivars:
      year variety/hybrid is identified
      year variety/hybrid is released
   iv. for management packages/options or components of package/options:
      year package was developed

d. adoption data: adoption lags, adoption rates, and ceiling levels. These parameters can be measured by collecting the following data:
   i. starting year of adoption
   ii. year technology is made available to farmers
   iii. current level of adoption (%)
   iv. expected ceiling level of adoption (%)
   v. year of ceiling level of adoption
   vi. current and projected area of adoption: regions production systems number of hectares
e. research cost
f. production cost (for improved and benchmark technology)
   i. input levels and costs (variable and fixed inputs)
   ii. reduction in unit cost of production with use of technology under farmers" management
   iii. expected yield gain achieved or yield loss avoided with use of technology under farmers' management
g. supply and demand elasticity (reflecting degree of responsiveness of producers and consumers to price changes; estimates are available from economic studies on demand and supply)
h. discount rate
i. planning horizon

Additional parameters like consumption, probability of success (for *ex ante* assessments) and spillover effects allow evaluation reflecting the various components of the research evaluation process.

Identifying opportunities for improving impacts of plant breeding research

D D Rohrbach[1]

The impacts of agricultural research projects and programs are assessed to justify past and future research investments. This presentation offers suggestions for using such assessments as additional means of improving the probability and level of future impacts of plant breeding programs. Impact is defined here to occur only when there is widespread adoption of products of plant breeding research.

Data on sorghum and pearl millet research from southern Africa are used to describe difficulties associated with an assumption that multiple variety releases necessarily imply impact. Examples provided showed releases occurring without adoption and of adoption occurring without significant productivity gains or cost reductions. The presentation identified information which can be gained by examining patterns of adoption and productivity change. This information can have a high payoff if used to re-target future research investments. For example, data assessing the adoption of a given type of cultivar may be used to justify a shift in the focus of a breeding program toward the development of complementary cultivars. Once adoption occurs, it is often easier to assess the preferences of farmers for the range of cultivars available at advanced testing stages. Assessments of the strengths and weaknesses of new varieties provide information on the next set of selection criteria to be used by plant breeders. Variety adoption may also justify an expansion of investments in complementary types of crop management research. Relatively limited gains in productivity occur only when a variety is changed. Much larger gains are derived from the adoption of improved management practices. As new varieties are adopted, potential benefits from associated improvements in crop management increase. This might create a need for research to narrow the yield gap between experiment stations, on-farm trials and farmer's fields.

An important contribution of the recent focus on impact assessment has been to draw the attention of crop scientists to the need to be interested in facilitating adoption of cultivars. In southern Africa, it was observed that the seed production and distribution sector is an effective constraint to achieving greater levels of impact at the farm level. In effect, scientists must take greater responsibility for technology transfer to complement technology development. The establishment of relatively simple adoption and impact monitoring systems can facilitate this process. Finally, impact assessments need to facilitate the evolution of research priorities. Efforts to simply quantify the value of past successes are too limited in focus and need to be complemented with analyses that consider implications for future investments.

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Adoption and impact of pigeonpea ICP 8863

M C S Bantilan and P K Joshi[1]

Background

Results from following the spread and impact of a cultivar, the wilt-resistant, medium-duration pigeonpea ICP 8863 (Maruthi), on the Deccan Plateau of India covering the states of Maharashtra, Andhra Pradesh, and Karnataka are presented. A study of the research process for fusarium wilt (*Fusarium udum)* indicates that the released variety ICP 8863 is a product of joint research and development (R&D) efforts by ICRISAT and the Indian National Agricultural Research System (NARS). The original collection of this material was a selection from P-15-3-3 obtained from Badnapur, Maharashtra. It was accessioned to the ICRISAT genebank and during evaluation was identified as wilt resistant. Further purification of the germplasm line was undertaken at ICRISAT Asia Center and multilocational screening was conducted through the Uniform Trial for Pigeonpea Wilt Resistance, a cooperative trial between the Indian Council for Agricultural Research (ICAR) and ICRISAT. Its release was facilitated in Karnataka as the incidence of wilt was worsening in the region. A total of 9 years of applied and adaptive research with ICRISAT/NARS joint efforts involved selection, multilocational screening, and further purification before the cultivar was released under the name of Maruthi in 1986. Four years were further invested in seed multiplication and front-line demonstrations by the Karnataka national program from 1986 to 1989.

Tracking the spread of ICP 8863

A systematic tracking approach was developed while complementary information from several sources were pieced together to form a composite picture of the spread of ICP 8863. They include secondary-level district data on area, production, and yield, seed sector sales, area estimates from the Department of Agriculture and Extension network, farm-level reconnaisance, and formal surveys. District-level data derived from the International Survey of Pigeonpea Diseases further provided benchmark information indicating the prevalence of fusarium wilt in the regions.

Seed production and distribution data from both public and private seed companies provided directions on the spread of the cultivar. The Karnataka State Seeds Corporation (KSSC) supports 14.7% of the annual total demand for ICP 8863 seed. The remaining 85% of seed demand relies on multiplication and distribution of seed through farmers. KSSC reported the sale of Maruthi seeds to have increased significantly from 49 t in 1990 to 140 t in 1994. The share of Maruthi in KSSC's total sale of

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all pigeonpea varieties increased from 32% in 1990 to 47% in 1994. It now covers the large pigeonpea tracts of several districts in Karnataka, including, Gulbarga, Bidar, Bijapur, and Raichur.

Another important lead information was obtained through reconnaisance surveys. Discussions with NARS scientists, extension personnel, and specialists and village assistants of the Department of Agriculture revealed invaluable directions for ground-truthing adoption levels. For example, reports by specialists of the Ministry of Agriculture in Karnataka indicated that about 116,120 ha were sown with Maruthi in the eight major pigeonpea-growing districts of Karnataka in 1994.

Adoption and impact surveys

Target areas for the adoption and impact study were identified from analysis of available district-level data: trends in area; production and yield; and growth rates within and across time and regions. A brief summary of the sampling scheme used for this study is as follows: the top two pigeonpea-producing blocks in top-producing districts were selected for a random selection of sample villages. A random sample of farmers was selected from pigeonpea-growing farmers in the sample villages. Survey modules were developed to include the following aspects for inquiry; basic farmholding information, land use/cropping system, adoption, input/output information, and postharvest information and seed utilization.

On-farm surveys covering three adoption regimes were conducted. The first covered the wilt-endemic regions of northern Karnataka, including the districts of Gulbarga, Bidar, and parts of Bijapur and Raichur. This area represents a favorable adoption environment where the state seed agency strongly supports seed production of released and recommended varieties. This area is also characterized by a good extension network from the State Ministry of Agriculture.

The second set of on-farm surveys explored the boundary districts of states bordering northern Karnataka. This included six boundary districts of the state of Andhra Pradesh and two districts in the southern part of Maharashtra. The area was covered to answer questions on the spread of varieties across states where the seed was not released, but where access to reliable sources of seeds was possible. Initial reconnaisance work gave information on the increasing popularity of Maruthi in the neighboring districts of the states of Andhra Pradesh and Maharashtra. The third set of on-farm surveys included villages in wilt-endemic areas of the major pigeonpea-producing state of Maharashtra. As information about ICP 8863's durable resistance to wilt reached farmers in the area, its demand grew steadily in the wilt endemic areas of the eastern part of the State. Presently, farmers essentially depend on a number of progressive seed-producing farmers who have limited access to seeds from the neighboring state of Karnataka. It is noted that ICP 8863 is not released in this State and this prevents the state seed corporation from undertaking seed production and multiplication. As demand grew in recent years, seed dealers in the area sought and were able to obtain limited certified seeds from KSSC.

Research evaluation framework

A 'simple non-traded goods' research evaluation framework, based on the economic surplus model, is chosen to estimate welfare gains from research. The assessment of benefits need the following basic data set:

a. production levels in the target area (i.e., the wilt- endemic region);
b. unit cost reduction based on cost structures obtained from the input/output module of on-farm surveys;
c. adoption rates and ceiling level of adoption in different adoption regimes;
d. base price of Rs 5468 (US$ 177) t^{-1} of pigeonpea;
e. discount rate of 8%;
f. supply elasticity of .2;
g. demand elasticity of .5;
h. planning horizon of 30 years; and
i. research costs.

Research costs on wilt resistance research in ICRISAT and the collaborating institutions in the NARS were estimated. For the purposes of this study, actual expenditures for fusarium wilt research were estimated with the guidance of scientists who were members of the ICRISAT fusarium research team, and administrative officers in charge of the budget. The breakdown of research cost was made on the basis of salaries of the research team members and proportions of scientists' time allocated to fusarium wilt research. Operating cost was estimated based on the total Legumes Pathology program's operating cost apportioned among the three major research activities implemented by the program (i.e., pigeonpea fusarium wilt, pigeonpea sterility mosaic, and the chickpea wilt complex). Similar imputations were made for the NARS counterpart funds.

Highlights of results

Results from the three sets of surveys are as follows. First, the rate of adoption of ICP 8863 increased in Karnataka, growing from 5% in 1987 to 55% in 1991, peaking at almost 60% between 1992 and 1993. It is expected that the ceiling level of adoption will hold at these values.

Second, the adoption trends obtained from the districts bordering northern Karnataka show that it took almost 2 years of lag before adoption of the first wilt-resistant variety took place. As a flow of information about the durable resistance to wilt of Maruthi reached farmers, adoption picked up fast, and access to certified seeds was possible from the neighboring district of Gulbarga. Maruthi is very popular among farmers in the adjoining districts of Andhra Pradesh although the variety is not released in this State. On-farm survey results reveal that adoption has reached 100% in certain villages near the district center.

Third, a constrained adoption scenario is clearly demonstrated by the on-farm survey results conducted in eastern Maharashtra. Farmers in this area report that wilt has been a yearly occurrence, and wilt incidence has been recorded to be as high as 68.8% in some districts. However, farmers do not have ready access to the wilt-resistant variety through the formal seed sector. The survey results reflect the consequences of the absence of seed sector support: a 2-year adoption lag is observed with a slow rate of adoption reaching less than 18% after 7 years. It is expected that widespread adoption will depend on farmer-to-farmer seed distribution unless release of this wilt-resistant variety or seed multiplication is facilitated in this State.

The net present value of benefits from fusarium wilt research is approximately US$ 75 million. This represents an internal rate of return of 73%. These results represent the benefits accruing to all the regions covered in the study.

Estimates of yield gain of ICP 8863 over the best cultivar obtained from the on-farm surveys is considerable. The percentage gain is 50% for the grain output, 45% for the fodder by-product, and 27% for stalk. Utilization of the wilt-resistant variety has been proved to increase production levels due to yield gains which translate to reducing the farmers' unit cost of production. Cost analysis for pigeonpea ICP 8863 was undertaken based on data observed on-farm, where input use, factor prices, and the best cultivar used by farmers before ICP 8863 were compared. Output information was also analyzed. The cost analysis indicates a unit cost reduction of 3820 Rupees (US$ 123) t^{-1} with the use of the improved variety ICP 8863. This is equivalent to a percentage unit cost reduction of 42%. The cost structures obtained from the on-farm surveys indicated that the major differences in input use are in seed rate and fertilizer application. Farmers using the local variety are observed to use higher seed rate for two reasons: 1. the seed of the improved variety has a price premium and losses due to wilt have to be compensated; and 2. farmers tend to use more farmyard manure on the local variety.

A summary of farmers' perceptions on benefits derived from the use of the wilt-resistant ICP 8863 which were documented include: 1. resistance to wilt; 2. shorter duration (160 days) of the crop; 3. suitability for both rainy and postrainy season crops; 4. suitability for both sole and intercrops; and 5. efficiency in input use (i.e., good response to irrigation and plant height ideal for plant protection operations).

Follow-up monitoring in the regions covered by the study provides further information on the impact of wilt-resistant ICP 8863. Wilt incidence in farmers' fields was found to be low in the Gulbarga area and farmers primarily attribute this improvement to the widespread cultivation of ICP 8863 (Maruthi).

Methodology for evaluating crop and resource management technologies

J Baidu-Forson[1]

Crop and resource management research products are sources of potentially large productivity gains in the semi-arid regions of western and central Africa. Some examples of these improvements are better information on the most suitable inputs, improved management techniques, such as methods and levels of application of inputs, and improved cultural practices. Farmers obtain new information through explanations on field days, recommendations in extension bulletins, intermediary contacts (non-governmental or public organizations), and fellow farmers.

The intangible nature of crop and resource management products, coupled with the existence of non-research sources of similar information to farmers, make it imperative to establish a causal link between research recommendations and changes in farmers' practices. It is also necessary to exclude modifications in farmers' practices that are motivated by policy and institutional changes independent of research output. Benefits to farmers and their welfare can only be measured when clear linkages have been established between changes in farmer practices and research recommendations. Reductions in unit costs of production and increased capacity to ensure self-sufficiency are indicators of improvement in individual well-being, while economic surpluses generated by adoption of research recommendations indicate social welfare.

The magnitude of research-induced supply shifts and elasticities of supply and demand determine the size and distribution of welfare benefits between consumers and producers. If, for example, due to the location-specific nature of crop and resource management recommendations, farmers face a perfect elasticity of demand, and if the input supply curve is perfectly elastic, then the resulting producer surplus can be estimated from enterprise budgets using mean yield and costs for adopters and non-adopters. The calculation of total benefit from each research-induced innovation requires adoption surveys, estimates and future projections of adoption, using the logistic diffusion function and varied adoption ceilings. Yearly costs are traced from all direct research and extension expense items. The costs and benefit streams are deflated by $1/(1 + r)^t$, over the entire duration of research to innovation utilization by farmers. The internal rate of return (r), the rate at which deflated benefits equal deflated costs, is then calculated to show return to investment in the relevant research and extension.

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Measuring sustainability impact of agricultural research

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During the last two decades, sustainability has generated a lot of interest within the international agricultural community. Concerns for poverty alleviation, food security, overcoming resources and environmental degradation, and high population growth rates have created an emphasis on sustainability impact of agricultural technology. There is a need to define and operationalize the concept of sustainability in order to measure this type of impact. To accomplish this, we review;

- Major definitions and interpretations of sustainability,
- Methods often used to measure the concept,
- Indicators of sustainability impact, and
- Implications of sustainability for agricultural research.

Most definitions of sustainability involve interpretations of the concept based on agroecology, equity, and growth perspectives. The agroecological perspective focuses on system resilience where sustainability is enhanced by diversity through the recycling of inputs internal to the system and the use of suitable farming systems. The equity interpretation stresses the protection of natural resources for the benefit of future generations. The growth perspective of sustainability emphasizes the need for society to live within the carrying capacity of the world resources and environment.

Most measurement methods available are either directional (non-quantitative) or quantitative (mainly trends analyses). Some scientists simply reject the notion that sustainability can and should be quantified. They fear and argue that sustainability cannot be quantified without simplifying the concept.

The concept of sustainable development has important implications for agricultural research policy. To ensure sustainability impacts, there is an identified need to: 1. integrate environmental considerations into the research process; 2. have a multidisciplinary and participatory approach to agricultural research; 3. involve collaborative efforts of IARCs, NARS, NGOs, policy makers, and donors for more effective and coordinated agricultural research; 4. aim at productivity improvement through technologies with high potential for sustainability; 5. secure property rights; 6. improve farmers' income to facilitate adoption of sustainable technologies and farming practices, and to achieve food security; and 7. integrate population growth and drought parameters into the agricultural development equation.

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Adoption and benefits from improved soil, water, and nutrient management research

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The specific case of Groundnut Production Technology (GPT) is used to examine adoption patterns and quantify the benefits of soil water and nutrient management research.

Background

Groundnut Production Technology was developed through an ICRISAT/NARS collaborative project, called the Legumes On-farm Technology Transfer Project (LEGOFTEN), designed to help enhance oilseed production in India. LEGOFTEN involved review and integration of essential technology components; popularization of improved technologies among extension staff and farmers, and technology transfer to accelerate adoption.

Methodology

Three districts in the state of Maharashtra where groundnut is grown on approximately 234,000 ha, were selected for this study. Parbhani, Nanded, and Yawatmal districts were targeted because GPT on-farm trials and demonstrations were conducted in this area during 1987-91. Groundnut is grown on about 80,000 ha in these three districts. A sample of 100 farmholdings were selected from seven sample villages across five sample blocks. Results reported here cover the phase 1 sample.

Sample farmers were interviewed using a structured questionnaire. Information was collected on the adoption of various components of the technology, their initial adoption year, modifications, if any, and the status of the technology adoption during 1993/94. Data were also collected on the cost and benefits of different components of the technology. Informal reconnaisance was undertaken to elicit information from agricultural development officers and traders dealing with components of GPT. Information was also compiled from the Training and Visit Units of the Department of the Agriculture.

The study on GPT - which encompasses various components of soil, water, and nutrient management - requires an assessment of adoption of each component over time and space. To measure the benefits from GPT investment, farm-level impact indicators, i.e., yield gains, higher income, cost saving, and gender-related effects, were evaluated. Economic surplus measures and internal rates of return were also estimated under various assumptions.

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Adoption of soil, water, and nutrient research

The soil management component, i.e., the raised-bed and furrow (RBF) method of cultivation, has become popular, especially among large- and medium-scale farmers. Constraints to adoption were specifically mentioned by small-scale and marginal farmers. These constraints include a lack of awareness of the technology; the high cost or non-availability of the 'bed former'; and restricted access to credit facilities. The study finds that farmers adopted the concept of RBF and modified the package according to their needs and resource endowments.

A high degree of spatial and temporal variability was observed in the adoption of soil-water-nutrient management research information. There was also differential adoption of various components of the technology package, e.g., 1. adoption of various components which relate to nutrient management ranged from 10% for ferrous sulphate, to 35% for gypsum, and 50% for single super phosphate; 2. adoption of the soil management component covered about 49% of the groundnut area; and 3. water management through sprinkler irrigation was adopted in about 11% of the groundnut area.

Other components, especially the sprinkler method of irrigation and use of some micro-nutrients, require a better market access before significant adoption can be achieved. The use of sprinkler irrigation is presently at an incipient stage of adoption, and with the subsidy extended by the Government of India to the purchase of sprinkler sets, a widespread utilization of this technology is expected.

Benefits of the groundnut production technology package

The realized farm-level benefits of GPT were calculated in terms of higher grain and fodder yield, increased income, better grain prices, and saving of important inputs, including irrigation and female labor for some tedious operations. The implications on gender-related issues and spillover effects of GPT techniques to other crops were positive. The GPT research and extension investment generated welfare gains to consumers and producers. The rate of return was positive but low (8-20%). While on-farm yield gains and corresponding unit cost reduction were high, the substantial adoption needed to attain high returns on investment has yet to be achieved.

Workshop Achievements

Workshop Achievements

J Baidu-Forson[1]

Topics covered at the Partners in Impact Assessment Workshop included: technologies suggested by NARS for joint impact analysis; impact assessment methodologies; and development of work plans for case studies. The discussions provided the necessary foundation for realistic NARS-driven development of protocols on the technologies targeted by national programs. Participants developed protocols for the following crops:

- Cameroon: sorghum variety S 35, and groundnut variety 55-437 in the Maroua, Mokolo, Mona, and Kaele districts.
- Chad: pearl millet variety GB 8735 in the Ouaddai, Biltine, and Kanem districts, and sorghum variety S 35 in the Guera, Mayo, and Kebbi districts.
- Mali: rotation and compost technologies.
- Niger: pearl millet variety Souna III in the Maggia and Gaya zones, and sorghum variety SEPON 82 in the Maggia and Goulbi zones.

The protocols established at the workshop provided information on details of activities to be pursued, methodology (ies) envisaged, team composition, and expected expenditures. Due to budget limitations, case studies selected for completion in 1995 were S 35 in Cameroon and Chad, and SEPON 82 in Niger.

A protocol for the evaluation of the level and impact of adoption of pearl millet varieties jointly developed by ICRISAT and the Institut national d'etudes et de recherches agricoles (INERA) will be developed further for implementation in 1996 if initial reconnaissance surveys provide promising indications.

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