Crop Improvement in Eastern and Southern Africa

Research Objectives and On-Farm Testing

A regional workshop held in Nairobi, Kenya, 20-22 July 1983
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Crop Improvement in Eastern and Southern Africa:
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Editor: Roger A. Kirkby
RÉSUMÉ

Un atelier a réuni un petit groupe représentatif de scientifiques travaillant à des programmes d'amélioration des cultures alimentaires en Afrique orientale et australe, pour discuter de la planification, de la conduite et de l'élaboration de ces programmes. Le débat a porté surtout sur les aspects méthodologiques, communs à la majorité des cultures réalisées par les petits fermiers et les plus susceptibles de permettre l'utilisation des résultats de la recherche.

On s'intéresse donc ici aux cultures locales et aux pratiques culturales, à l'organisation de l'aide institutionnelle pour améliorer les cultures, aux objectifs particuliers des programmes et au mode d'établissement de ces objectifs, enfin aux méthodes d'évaluation employées pour formuler une nouvelle recommandation sur les travaux de vulgarisation. On résume aussi la séance de discussion qui a porté sur l'organisation des programmes d'amélioration des cultures, l'établissement des objectifs techniques, l'application des critères de sélection, la méthodologie pour les essais tous terrains et sur les fermes et, enfin, l'orientation de la recherche.

RESUMEN

Este seminario reunió un pequeño grupo representativo de científicos que trabajan en programas de mejoramiento de cultivos alimenticios en África oriental y meridional con el ánimo de discutir la planificación, la ejecución y el desarrollo de tales programas. El énfasis de la discusión recayó en aquellos aspectos metodológicos, comunes a la mayoría de los cultivos sembrados por los pequeños agricultores, que tienen la probabilidad de influir más en que los resultados de la investigación sean utilizados por el agricultor.

Entre estos trabajos se encuentran breves recuentos de las variedades locales y las prácticas de cultivo empleadas actualmente, la organización institucional para el fitomejoramiento, los objetivos específicos de los programas y su sistema de establecimiento, así como los procedimientos de evaluación empleados para llegar a las nuevas recomendaciones para los trabajos de extensión. También se incluye en este volumen un resumen de la sesión de discusión sobre la organización de los programas de fitomejoramiento, la fijación de los objetivos técnicos y la aplicación de los criterios de selección y la metodología para los ensayos tanto en fincas como en localización múltiple. Varios temas de política fueron identificados.
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INTRODUCTION

METHODOLOGICAL ISSUES RELATED TO FOOD-CROP IMPROVEMENT IN EASTERN AND SOUTHERN AFRICA

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HISTORICAL BACKGROUND

Crop improvement, defined here as a series of research activities resulting in the production of new germ plasm and crop-management practices that benefit the producers and consumers of a crop, has a long history in eastern and southern Africa. A large amount of rigorous scientific work has been conducted, often with relatively rudimentary facilities, since the first research stations were established (e.g., Umbeluzi station, Mozambique, 1903). Initially, research concentrated upon cash and particularly export crops, with a few notable exceptions such as the Tanzania sorghum program that began in 1947 (Doggett 1970). Research on subsistence food crops has developed mostly since 1960, with much of it coming after Leakey's (1970) review. During the past decade, five trends have developed in food-crop research, and it is these trends that have provided the background for this publication.

The first trend has been the gradual expansion of crop-improvement research to encompass a wider range of crop species. In most countries, improvement of subsistence food crops began with only one or two commodities of primary importance — often maize because of its extensive use in areas of high cropping potential and popularity among the growing populations in urban centres (Harrison 1970). Early in the 1970s, the resources devoted to sorghum research increased as the importance of this crop for the much larger areas of relatively low cropping potential in semi-arid environments, and for the generally poorer rural populations living there, was realized. Mushonga, in his presentation, describes the new focus of sorghum and millet research in Zimbabwe since independence added to the research mandate a new type of clientele, the communal farmer, whose land generally has less cropping potential and who has different requirements for technology. Improvement programs for grain legumes and oilseeds, for example, began partly due to concerns over nutritional issues related to the availability of protein and concentrated calorie sources.

More recently, increased attention has been given to cassava and sweet potato research, which have a long but rather sporadic history in the region. This is partly a result of more farmers in eastern
Africa turning to these crops as sources of food and cash income because they are unaffected by the vagaries of government-controlled crop pricing and marketing systems (Kirkby 1983).

In the near future, we are likely to see this general trend extend to the formation of new programs for other traditional crops that have been even more neglected by research. These include bananas and plantains (staple food crops in large areas of Rwanda, Burundi, Uganda, and Tanzania) and indigenous species of leafy vegetables, which in many places provide an essential component of the family diet in return for very few inputs. The papers by Osiru and Mukiibi and Kwapata and Edje describe proposed research in these two areas.

It is pertinent to ask whether or not there are lessons to be learned from well-established programs by those launching new research efforts. If so, the chances of developing technology that will be used by and benefit farmers within a reasonable period of time might improve. This workshop was planned, in part, to provide an opportunity for the exchange of such information.

REGIONAL COOPERATION

Indigenous research capacity has expanded as universities increase their output of agricultural graduates and a greater number of postgraduates take up research posts within national institutions. Many research programs are now staffed entirely by local scientists.

Indigenous staffing, largely responsible for the rising interest in traditional food crops, has greatly increased opportunities for planning and conducting sustained research programs. It has not always been accompanied, however, by adequate communication and sharing of technical experience among countries, despite many environmental similarities and the use of similar cropping systems. The demise of the East African Community in 1977 resulted in the cessation of the biennial Eastern African Cereals Research Conferences and the dissolution of the East African Sorghum and Millets Improvement Programme (although the core of this program has continued as the national program of Uganda, as described in the paper by Esele). Since 1977, therefore, most scientists have had few opportunities to meet with their colleagues to discuss the status of crop-improvement research.

Fortunately, the development of a series of regional programs linking national efforts is a second detectable trend. It was set by Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT) and Centro Internacional de la Papa (CIP) in initiating eastern African regional programs for wheat and potato, respectively, and has been followed by regional coordination for research on sorghum (Semi-Arid Food Grains Research and Development (SAFGRAD)), maize (CIMMYT), highland oilseeds (IDRC), and cassava (International Institute of Tropical Agriculture (IITA)) and groundnuts in southern Africa (International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)). These regional activities provide considerable potential for exchanging germ plasm and ideas and for peer-group review (Gebrekidan 1982; ISAR 1982). Regional activities are, perhaps, most effective when organized on a modest scale to be responsive to the needs expressed by scientists in national programs.
ORGANIZATION OF CROP-IMPROVEMENT PROGRAMS

The third trend in crops research has been the organizational focus on multidisciplinary crop-commodity research teams. Typically, a full team would include a plant breeder, an agronomist, and relevant disciplines from the plant-protection field. Originally, only research on cash crops was organized in this manner, but now an increasing number of national teams has been formed to study the major food crops as research resources, particularly trained personnel, become available.

Formation of a multidisciplinary team is a necessary, but not entirely sufficient on its own, condition for ensuring that crop-improvement research is tackled in a holistic manner, with a rational set of priorities among the objectives. Excessive specialization during postgraduate training can make effective cooperation more difficult. Efficient use of limited personnel resources within a country, however, can present other problems with respect to coordination, particularly when national responsibility for research rests with a government agency and many well-trained scientists reside in the university. The paper by Shekour discusses some of these issues as they relate to Ethiopia, where an elaborate system of annual planning and evaluation meetings has been developed to coordinate research undertaken cooperatively by different institutions within a large and ecologically varied country.

A second organizational issue is the triangular relationship among the crop-improvement program, the extension service, and the farmer. The need for information exchange between crop-improvement researchers and farmers is discussed in the next two sections. As well, the presentation by Haile addresses one approach to the subject.

FARMING SYSTEMS RESEARCH

A fourth trend appearing in most countries has been the development of programs for cropping systems research or farming systems research (FSR). This move represents a convergence of views of technically-trained agricultural scientists who are conducting research to improve farmers' intercropping systems (Keswani and Ndunguru 1980) and agricultural economists seeking a more appropriate role in technology generation than ex post evaluations. The introduction of FSR (reviewed by Collinson (1982)) represents an attempt to institutionalize a set of procedures for developing useful new technology that should be more rational and realistic than if each commodity research program were to continue pursuing, in isolation, a strategy for increasing the production of a particular commodity. An example of the effect of the commodity orientation upon a program's objectives is seen in crop-substitution experiments aimed at removing interference from other crops that farmers grow in association or rotation with the commodity of interest.

Farmers do not plan the production of one crop in isolation from another and a program's objectives may change depending upon whether or not this fact is taken into account (Collinson 1968). Some crop-improvement programs already do this, and some may feel that their current priorities, arrived at through good judgment on the part of the technical staff, should merely be confirmed by formal FSR. Percy (1975), for example, believed that most plant-breeding and
insect-control research on cotton in western Tanzania would not have been different if an explicit orientation toward farming systems had been used because new cotton varieties gave greater benefits under the adverse conditions found on farms than under the maximum-yield conditions applied to most experiments. This occurred because a major selection criterion had been resistance to jassid leafhoppers, an important yield-limiting factor, especially for farmers who cannot afford insecticides. On the other hand, Percy felt that a FSR orientation would have changed the design of agronomic research, which had developed high-yielding practices based upon increased labour inputs (e.g., making ridges) that may not have been feasible. It is now accepted that peasant farmers experiment with new methods of growing crops, introduce new species or varieties (Nankumba 1979), and show a keen interest in new technology developed at research stations when they feel there is a need. The fact that many existing agricultural recommendations have not been more extensively adopted by small-scale farmers and crop production in Africa is failing to keep up with or surpass the rate of population growth cannot be attributed solely to infrastructural or extension-service deficiencies; first, the technology must fit the farmers' needs and situation.

FSR programs are intended to complement crop improvement and other research station-based activities by conducting interdisciplin­ary on-farm research in defined areas of the country. By eliciting the participation of farmers, it is hoped that an improved understanding of the constraints and underexploited potential of the systems in the area can be gained and opportunities for technology generation and testing and adaptation of technology to local circumstances, if necessary, can be identified.

Gaining a better understanding of what one sets out to improve upon is common sense, but implementing this strategy can present several problems, particularly where the number of trained personnel capable of conducting conventional research is still inadequate. Eicher and Baker (1982) have suggested that, because FSR depends so much upon there being strong commodity research to provide the basis for technical innovation, the overenthusiastic introduction of FSR could divert critical resources away from crop improvement. Certainly, research institutions need to address the question of what constitutes a strong program for crop improvement. Is strength measurable in terms of budget and personnel, by a program's impact on the well-being of producers and consumers, or its ability to make use of new information on farmers' needs? Crop improvement and FSR need to cooperate closely, but their interrelationships at present are neither well defined nor obvious. At the same time, crop-improvement programs may find increasing difficulty in integrating national priorities with the narrowly defined priorities identified at the farm level as more on-farm work reveals differences between farming systems that call for subsets of objectives and criteria for different groups of farmers. Crop-improvement programs require effective linkages at the national level with other disciplines in addition to those involved in on-farm research if they are to generate useful technology, particularly in the field of postharvest technology and food utilization. The sorghum breeder, for example, cannot necessarily decide alone, or even in conjunction with the FSR economist and agronomist, the appropriate grain type to use as a selection criterion in developing new cultivars for an area where farmers currently grow white grain types but suffer serious losses to birds. Brown-seeded bitter types that deter birds could be a better option but only if dehulling equipment, capable of producing a quality
of grain that is acceptable to the consumer, can be manufactured and distributed (Forrest and Yaciuk 1980).

**RESOURCE-EFFICIENT AGRICULTURE**

The fifth recent trend in research orientation is the emphasis given, for several reasons, to increasing production while maintaining relatively low levels of inputs. Sometimes this is due to a redistribution of the population to drier, lower cropping potential areas of a country in response to pressures on land elsewhere (e.g., Kenya, as pointed out in Onim's paper); the enfranchisement of a poorer group of farmers previously ignored by research, as in Zimbabwe (see paper by Mushonga); concern that the benefits of agricultural research should reach the poorest farmers; and a shortage of foreign exchange for importing agricultural chemicals (Nyerere 1983). Multilocation testing of new crop cultivars has long been the standard technique for taking into account the heterogeneity of soils, climate, and pest distribution within a country (e.g., a national network of sites has been particularly well developed in Uganda, as discussed in the paper by Esele). However, less productive soil types are typically underrepresented on experimental stations and other managed sites due to earlier emphasis upon large-scale agriculture and cash cropping. Fertility levels and weed flora also tend to become unrepresentative of surrounding farms due to intensive management. This has led to concern over the adaptation and utility of varieties developed under and for high-input conditions (IITA 1982). The diamond design of treatments to verify the performance of a new cultivar and management practice under both recommended and farmers' conditions is a technique now widely used to test for interactions before the final release of recommendations. This design was first made popular by Allan (1969) in eastern Africa.

The evaluation of technology, through feedback, can assist in the design of appropriate program objectives, but a program that sets out to develop resource-efficient technology would probably want to introduce relevant criteria at an earlier stage by examining existing systems. Traditional low-input systems are often highly complex and incorporate compensatory mechanisms that reduce the risk of total failure during a poor season but may limit responsiveness to more favourable conditions. In Somalia, climatically the harshest of the three countries reporting on sorghum research at this workshop, sorghum is not only a food crop but also provides the straw required for feeding livestock, which generally comprise the most stable component of the farming system. Furthermore, much of the crop is ratooned to ensure the growth of a small second crop without recultivating during an unreliable rainy period, even though a second sown crop would have the potential to produce a greater yield (see paper by Hashi).

If farmers' strategies suggest that improved resource-efficient cultivars may be different in habit from those developed under a high-yield objective, programs need to ensure that the internal allocation of resources reflects a logical set of priorities. This may include a decision on whether to breed for two or more distinct sets of conditions or retain and advance carefully selected segregants for ultimate testing under the diverse range of conditions. Developing recommendations for suboptimal conditions and low-input levels is still a controversial topic and may cause a crop-improvement...
program to devise its own novel set of selection criteria, which may differ from those traditionally found in textbooks on plant breeding.

Similarly, when evaluating technology, the disciplines involved in crop improvement are usually less familiar with the procedures for conducting realistic on-farm tests than they are with collecting local germ plasm from farmers. The presentations by Zeigler and Manassé and Önün suggest two possible ways of conducting such evaluations.

OBJECTIVES OF THE WORKSHOP

This workshop was organized by IDRC to bring together a small representative group of scientists working in food-crop improvement programs in eastern and southern Africa to discuss planning, conducting, and developing such programs. The intention was to concentrate upon those methodological aspects, common to most crops grown by small-scale farmers, that contribute most to the likelihood that the research results will be utilized by the farmer.

The participants were asked to prepare brief accounts of the local varieties grown and cultivation practices currently employed in their country, institutional organization for crop improvement, specific objectives of their programs and how these were established, and evaluation procedures used in arriving at a new recommendation for extension. Comments were also requested on any modifications that had been introduced into the objectives or evaluation procedures, including reasons for the changes. The reports submitted form the bulk of these proceedings.

During the workshop, the participants were divided into three working groups and asked to discuss and formulate guidelines or recommendations applicable to crop-improvement programs in the region along the following three interdependent themes and any others agreed upon by the participants.

(1) Organization of crop improvement programs -- This involves (a) the mechanisms for effective coordination of crop-improvement activities when more than one scientific discipline or research institution is involved and/or the crop is grown in more than one distinct agroecological region or under more than one type of farming system within the country; (b) the relationships between crop improvement and farming systems research programs with respect to designing and evaluating crop technology; (c) the roles and organization of multilocation and on-farm testing and their linkages with crop improvement, farming systems research, and extension; (d) procedures for the release of a variety or agronomic recommendation; and (e) appropriate training for young scientists joining multidisciplinary crop-improvement programs.

(2) Setting technical objectives and the application of selection criteria -- Topics discussed included (a) useful sources of information on the specific requirements of producers and consumers for new cultivars or management practices; (b) methods by which programs might improve their definition of the technical objectives and selection criteria and may assign priorities to the objectives; and (c) the implications, at the crop-management level, of the technical objectives set for field experiments.
Methodology for multilocation and on-farm testing -- This theme involved discussions on (a) the differences in functions among multilocation testing, researcher-managed on-farm testing, and farmer-managed on-farm testing; (b) approaches to the selection and management of multilocation-testing sites; and (c) selection of on-farm testing sites, methods of eliciting farmer participation in conducting and evaluating on-farm tests, management of experimental and nonexperimental variables, and the types of data to be recorded and methods of combining the analyses of several parameters and comparing analyses across sites.

A summary of these discussions forms the final chapter of these proceedings.


