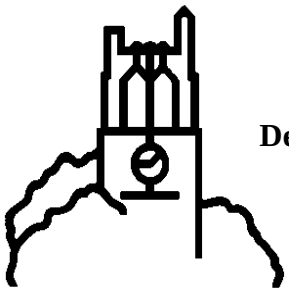
MSU International Development Working Papers

Increasing Seed System Efficiency in Africa: Concepts, Strategies and Issues

by

Mywish Maredia, Julie Howard, and Duncan Boughton, with Anwar Naseem, Mariah Wanzala, and Kei Kajisa

MSU International Development Working Paper No. 77 1999



Department of Agricultural Economics
Department of Economics
MICHIGAN STATE UNIVERSITY
East Lansing, Michigan 48824

MSU Agricultural Economics Web Site: http://www.aec.msu.edu/agecon/
MSU Food Security II Web Site: http://www.aec.msu.edu/agecon/fs2/index.htm

MSU INTERNATIONAL DEVELOPMENT PAPERS

Carl Liedholm and Michael T. Weber

Editors

The MSU International Development Paper series is designed to further the comparative analysis of international development activities in Africa, Latin America, Asia, and the Near East. The papers report research findings on historical, as well as contemporary, international development problems. The series includes papers on a wide range of topics, such as alternative rural development strategies; nonfarm employment and small scale industry; housing and construction; farming and marketing systems; food and nutrition policy analysis; economics of rice production in West Africa; technological change, employment, and income distribution; computer techniques for farm and marketing surveys; farming systems and food security research.

The papers are aimed at teachers, researchers, policy makers, donor agencies, and international development practitioners. Selected papers will be translated into French, Spanish, or other languages.

Individuals and institutions in Third World countries may receive single copies of papers published since 1993 free of charge. Requests for copies and for information on available papers may be sent to:

MSU Bulletin Office
10-B Agriculture Hall
Michigan State University
East Lansing, Michigan 48824-1039
U.S.A.

Information concerning how to purchase MSU International Development Papers is included in the back of this publication and requests should be sent to:

MSU Bulletin Office
10-B Agriculture Hall
Michigan State University
East Lansing, Michigan 48824-1039
U.S.A.

INCREASING SEED SYSTEM EFFICIENCY IN AFRICA: CONCEPTS, STRATEGIES AND ISSUES

by

Mywish Maredia, Julie Howard, and Duncan Boughton,
with Anwar Naseem, Mariah Wanzala, and Kei Kajisa

December 1999

This paper is published by the Department of Agricultural Economics and the Department of Economics, Michigan State University (MSU). Funding for this research was provided by the Food Security II Cooperative Agreement (PCE-A-00-97-00044-00) between Michigan State University and the United States Agency for International Development, through the Africa Bureau's Office of Sustainable Development, and Agriculture, Natural Resources and Rural Enterprise Division (USAID/AFR/SD/ANRE).

Maredia is Adjunct Assistant Professor, Howard is Visiting Assistant Professor, Boughton is Visiting Associate Professor, and Naseem, Wanzala and Kajisa are doctoral candidates in the Department of Agricultural Economics, Michigan State University. The authors thank Dr. Richard Ward of MSU's Department of Crop and Soil Sciences for discussions that improved our understanding of the technical aspects of seed production and Dr. Valerie Kelly for her review of the paper.

ISSN 0731-3438

Published by the Department of Agricultural Economics and the Department of Economics, Michigan State University, East Lansing, Michigan 48824-1039, U.S.A.

EXECUTIVE SUMMARY

BACKGROUND

Seed can play a critical role in increasing agricultural productivity: seed, together with environment, determines the upper limit of crop yields and the productivity of all other agricultural inputs to the farming system. In the mid-1970s, governments and donors recognized the critical role of seed in agricultural transformation and began to provide substantial support for seed system development. Most of these resources were used to establish large-scale parastatal seed corporations, technical laboratories, processing plants and certification departments. In Africa these efforts achieved only limited success in a few crops such as hybrid maize and sorghum, leaving the majority of smallholders unserved. Parastatal seed systems supplied only about 10% of total seed planted each year. About 60-70% of seed used by African smallholders is saved on-farm, and the remaining 20-30% is borrowed or purchased locally.

The key problems faced by the large-scale parastatal seed organizations were (1) **high costs of production and distribution** related to consistently low levels of effective demand, and to the high cost of transport from centralized seed production facilities to rural areas; (2) **a relatively narrow range of crops/varieties** that did not meet smallholder needs; (3) **inconsistent seed quality**; and (4) **escalating financial problems** in countries where government programs provided subsidized seed to farmers, but budgetary transfers to compensate parastatals for the subsidies were delayed or not made. As a result of these problems, seed parastatals grew increasingly dependent on state or donor subsidies during the 1980s. Many of them were subsequently dissolved and support to other components of the seed system was dramatically reduced as part of structural adjustment programs implemented across Africa.

Although seed parastatals were not effective in meeting the needs of smallholders, for-profit seed firms have not yet filled the gap and smallholder access to improved varieties has worsened in a number of countries following economic reforms. Since the mid-1990s, non-governmental organizations (NGOs) have become increasingly active in varietal testing and promoting the development of smallholder seed firms. Given the critical role that improved varieties play in increasing agricultural production, a key question is how to facilitate the development of a seed system that is capable of generating, producing and distributing new seed varieties that meet the needs of all farmers in a cost-effective way.

OBJECTIVES AND METHODS

The purpose of this paper is to provide a conceptual framework that can be used by agricultural leaders, administrators, policy makers, and seed program managers to (1) understand key factors affecting seed system development; and (2) compare organizational and institutional strategies for increasing seed system effectiveness. A literature review of recent studies on seed system

development in Sub-Saharan Africa (SSA) was undertaken to achieve these objectives. The studies reviewed included published and unpublished reports, monographs, and case studies.

WHAT IS THE SEED SYSTEM?

The seed system is composed of organizations, individuals and institutions involved in different seed system functions, i.e., the development, multiplication, processing, storage, distribution and marketing of seeds. The seed system includes both informal (or traditional) and formal sectors. The informal sector is composed of individual farm households, each carrying out most seed system functions on its own with little or no specialization. The formal sector is made up of public and private organizations with specialized roles in supplying new varieties. Different types of seeds flow from organizations and individuals in one stage of the seed chain to the next through separate informal and formal seed supply channels. Rules and regulations such as variety release procedures, intellectual property rights, certification programs, seed standards, and contract laws influence the structure, coordination and performance of the seed system.

A well-functioning seed system is defined as one that uses the appropriate combination of formal, informal, market and non-market channels to stimulate and efficiently meet farmers' evolving demand for quality seeds.

HOW SEED SYSTEMS EVOLVE

The seed system passes through several phases as it evolves from a traditional to an advanced system.

- In **phase 1**, the informal seed system predominates; most farmers save their own seed or obtain seed from nearby farmers or villages, and the rate of new varietal development and adoption of new seeds is low.

- During **phase 2**, seeds of improved varieties developed by publicly-funded research begin to replace local varieties, use of complementary inputs (e.g., fertilizer) is limited but increasing, and an emerging private sector is involved in multiplication and distribution of public varieties.

- During **phase 3**, the private sector begins to play an active role in research and development, particularly in developing hybrids and seeds for specialized cash crops. Seed distribution systems become more organizationally varied and decentralized.

- In **phase 4**, the agricultural sector as a whole and the seed system in particular are well developed. Commercial seed production and marketing are common, effective seed laws and regulations are in place, linkages with actors outside the seed sector are well established, and the use of improved seed is widespread.

Correspondingly, the rules, regulations, and infrastructure coordinating the components of the seed system evolve to allow organizations to specialize in different functions of the seed system. The public sector may specialize in basic research and research on subsistence crops, and in regulating the seed system. The national and international private sectors increasingly focus on research, production and marketing of seed for hybrids, specialty crops, vegetable crops, and commercial food and fiber crops. NGOs try to fill the gap by concentrating on multiplication and distribution of seed for crops and farmers not targeted by the private sector.

The transformation process described above should not be interpreted as the simple linear progression of a national seed system from an informal to a formal system. Seed systems for different commodities follow distinct development paths as they move from one phase to the next. The path for a hybrid maize seed system will be different from that for millet or cowpea, and those systems may never reach the technical, organizational and institutional complexity of a hybrid maize seed system. The seed system for maize in the advanced phase (such as in the U.S.) may be composed only of formal seed channels, with the private sector meeting the market demand for hybrid seed each season. On the other hand, seed systems for beans, wheat, cowpeas, and groundnuts, even in a mature phase, may have all the components of the seed system, with both formal and informal sectors playing important roles in meeting the demand for seed.

STRATEGIES TO PROMOTE SEED SYSTEM DEVELOPMENT

Past donor and government efforts to improve African seed systems were based on a narrow view of the transformation process, focusing on the development of the formal sector. These organizations promoted the use of certified seeds and hybrids but were unsuccessful in building demand from the smallholder sector.

The studies reviewed here by contrast stress the complexity of each phase of seed sector development and the dynamic roles of a range of public, private, formal and informal seed organizations in meeting smallholder seed needs and facilitating the transformation process. There are three key points. First, **during transformation, the importance of the informal seed sector will decline relatively (but not necessarily absolutely) as the seed system evolves.** Second, **building horizontal linkages between the informal and formal sectors at each functional level** (e.g., research and development, seed production) **is a critical step** in facilitating transformation. Third, **the public sector has a vital role to play in the transformation process** in: (a) providing public goods that are essential to the functioning of both formal and informal sectors, including basic research and adaptive and applied research targeted to crops and farmers that are of less interest to the private sector; (b) developing and enforcing regulations for a heterogeneous seed system; (c) facilitating formal-informal sector linkages at different functional levels, including the promotion of new, more specialized private firms; and (d) distributing seed or seed vouchers following disasters.

Increasing effective demand for improved varieties among smallholders. The nature of seed demanded by farmers differs. Large- and medium-scale farmers use markets to purchase uniform genetic materials that are highly responsive to chemical inputs and embody specific characteristics (e.g., color, uniformity of grain size) rewarded by the market. By contrast, more subsistence-oriented smallholders may value characteristics such as drought tolerance, early maturity or good storage more than fertilizer responsiveness. Because of the small size of their land holdings, mixed cropping practices, and strategy of minimizing production risks by diversifying the variety base, smallholders also demand relatively small quantities of seed, but for a number of varieties of the same crop, and recycle seed over more seasons than larger commercial farmers.

New varieties must have significant yield/quality advantages over traditional varieties to offset the increased costs incurred by seed users in purchasing the seed. Successful past examples include the semi-dwarf wheat and rice varieties that triggered the Asian Green Revolution, flint hybrid maize in Malawi, CSH-1 hybrid sorghum, and MBH pearl millet in India.

Strategies to improve seed quality must begin with strengthening the public agricultural research and development sector on a long-term, sustainable basis. It will be especially important to build the capacity to move from homogeneous seed recommendations to the development and dissemination of varieties targeted to specific agroecological zones and the needs of different groups of farmers. To facilitate this process, target groups of farmers need to be defined more precisely, zoning of breeding plots improved and management incentive systems should be developed to reward researchers and extension agents when new technology is adopted by target groups.

Strengthening extension programs to increase farmer knowledge about the benefits of using new seed and transmit information about farmer preferences to researchers will also help increase the demand for new seed. Initiatives that improve post-harvest product utilization, expand output markets, and lower production risks are also important. Farmers will pay more for new seed if their expected returns are greater because of reduced storage losses or lower risks. Thus, measures to improve the downstream sectors of the economy are as important as strengthening the seed system itself.

Decreasing the cost of seed production and distribution. An important way to reduce the cost of seed production and distribution is to **promote the production of different seed commodities by seed suppliers likely to have a comparative advantage in producing them**. The relative importance of formal and informal seed suppliers is determined in part by biological and technical factors associated with seed production, multiplication, processing and distribution. In general, seed of self-pollinated crops (e.g., many grain legumes) can be easily multiplied by farmers and are more suited to dissemination through the informal seed system, regardless of the economic status of seed users. For cross-pollinated crops (e.g., maize, sorghum and millet) both formal and informal seed systems are important.

In addition, crops that have a high multiplication factor and relatively low seeding rate, such as hybrid maize, sorghum and millet, are more attractive to the formal seed sector because fewer multiplications are required and, at each stage, there are smaller quantities to process, store and distribute. By contrast, grain legumes are characterized by low multiplication factors and high seeding rates, and these are consequently the least attractive crops for large centralized seed companies to handle.

The relative importance of formal and informal systems of seed supply will also depend on the availability of new varieties with significant yield and/or quality advantages. Recurrent sales of improved seed depend partly on the ability of the formal research and development system to provide a steady flow of new varieties to maintain farmer interest. In addition, the rate at which new varieties succumb to biotic stresses both in the field and during on-farm storage will determine the level and frequency of purchases from the formal seed system by farmers. For example, wheat and rice are particularly susceptible to insect and disease pests, creating a demand for pest-resistant varieties as they are released from research systems.

Improving infrastructure, rules and regulations. Key to reducing the cost of producing and distributing seed is the improvement of transport and information infrastructure, and the revision/enforcement of laws and regulations to lower the risks and transactions costs of doing business in the seed sector, especially for smaller firms and farmer groups. For example, extension programs and labeling and quality regulations reduce the cost of getting reliable information about new varieties. Market information systems can also reduce seed suppliers' costs in discovering farmers' preferences, and the costs of inventory, storage, and waste are reduced if suppliers can anticipate farmer demands on time. Inappropriate laws and regulations may inhibit the emergence of private initiatives in seed production and marketing, e.g., agreements that award monopoly rights for all varieties developed by the public sector to one parastatal or private firm.

One challenge ahead will be to revise seed regulations in a way that facilitates the development of a heterogeneous, competitive group of seed producers while protecting the rights of all producers and consumers. Many regulations on the books today were fashioned for formal sector seed enterprises and discourage farmer-based seed production, e.g., stringent variety release procedures, plant breeder's rights and plant variety protection laws. For example, compulsory certification constrains the multiplication and distribution of seed of commodities (e.g., open-pollinated maize and sorghum) whose low seed yields and profit margins cannot absorb the costs of stringent and frequent inspections needed to comply with certification standards. Removing compulsory seed certification and restrictive trade licensing requirements would permit the production of quality seed by smallholders and sale among neighboring farmers. In addition, seed companies would be able to involve smallholders in contract seed production more easily.

Reduce the learning and transactions costs for new seed enterprises. Training new seed producers and reducing the cost of doing business for formal and informal seed sector participants are other important ways to cut the cost of seed production and distribution.

For example, several NGOs in Zimbabwe and Zambia in partnership with the public extension service:

- provide links from small seed-producing firms to national and international research centers to get information and seed of appropriate varieties;

- train and supervise farmers in seed production, selection, storage and marketing;

- provide basic training on seed and bookkeeping to rural shopkeepers who are potential agents for formal sector seed suppliers; and

- provide working capital for input stocks and aggregate orders to be filled by large input supply companies.

EMERGING ISSUES AND RESEARCH NEEDS

Developing a seed system based on greater integration, broader participation, and decentralization is an attractive concept but raises several issues. The first concern is the potential risk posed to small-scale seed entrepreneurs if seed stocks go unsold. Mechanisms for assessing the potential demand for seed and protecting the seed seller against the liability for unsold stocks need to be explored. A second issue involves the regulatory role of the government in an increasingly decentralized seed system. Key questions include: How will farmers be assured of the seed quality? How can seed enterprises and farmers be assured that their contracts will be honored?

Country-level case studies could provide useful information concerning (1) the economics of smallholder seed organizations; and (2) the costs and benefits of alternative interventions to strengthen effective demand for improved varieties and improve formal-informal seed sector linkages, including measures to facilitate the establishment of private seed firms.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF BOXES

1. INTRODUCTION

Without seed there would be no agriculture. The genetic and physical characteristics of seed determine the productivity of other agricultural inputs and cultural practices within the farming system. Improving the genetic and physical properties of seed can trigger yield increases and lead to improvements in agricultural production and food security. In order for seed to act as a catalyst in agricultural transformation, however, improved seed has be made available to a broad base of farmers on a continuing basis.

Donors and governments have invested considerable sums in seed program development over the last several decades. FAO spent $80 million on 120 seed projects in 60 countries in the 1980s and early 1990s; the World Bank supported over 100 seed projects in developing countries from 1975 to 1985, including 40 in SSA; and USAID provided long-term support to public seed agencies in 57 countries from 1958 to 1987 (Wiggins and Cromwell 1995; Cromwell 1996; Venkatesan 1994).

Most of this funding was used to establish formal seed systems – large-scale parastatal seed agencies, technical laboratories, processing plants, and certification departments. The aim of developing such formal seed systems was to promote the use of high-yielding certified seeds, but these generally reached only a small proportion of farmers living in the highest potential areas. The public sector monopolies were often overly bureaucratic and inefficient (Srivastava and Jaffee 1993).[1]

In the face of Africa's mounting food crisis, the need to improve national seed programs is more critical than ever before. The failure of seed parastatals, the reduction in public research services, and the public sector withdrawal from input supply functions following the implementation of structural adjustment programs of the 1980s accentuate the need for alternative approaches to seed system development.[2]

Creating more effective seed systems in African countries will require a broader-based approach than the formal sector interventions of the past. It will be necessary to build on existing informal farm-level seed systems, strengthening and integrating them with the desirable formal systems of

---

[1]Inefficiently-run seed parastatals produced less seed than needed at a high cost. The Tanzania Seed Company provided less than 14% of Tanzania's certified seed needs in the mid-1980s, while recording operating losses on seed sold at roughly twice the price charged by competitors (Budden 1986, cited by Cromwell 1992a). In The Gambia, the Seed Multiplication Unit of the Department of Agriculture reported a turnover of less than 10% of its US$89,600 expenditure in 1984-85, and at the same time had 'a limited impact on the national seed supply position' according to a 1987 evaluation (Cromwell 1992a).

[2]As a result of structural adjustment programs seed parastatals were privatized and/or other private seed companies allowed to operate in many countries. For example, in Malawi, Cargill bought a controlling portion of the National Seed Company, Pioneer Seed Company was allowed to operate for the first time in Zimbabwe and Zambia, the assets of the bankrupt Ghana Seed Company were taken over by a local business, and public sector seed activities were privatized in Nigeria (Wiggins and Cromwell 1995).

the future. We know of no simple blueprint for doing this. The purpose of this paper is to provide a conceptual framework that can be used by agricultural leaders, administrators, policy makers, and seed program managers to (1) understand key factors affecting seed system development; and (2) compare organizational and institutional strategies for increasing seed system effectiveness. A literature review of recent studies on seed system development in SSA was undertaken to achieve these objectives. The studies reviewed included published and unpublished reports, monographs, and case studies.

We begin by defining the seed system in Section 2, then describe the characteristics and performance of seed systems in SSA in Section 3. Section 4 presents a conceptual analysis of seed system development, Section 5 discusses strategies to promote seed demand and supply linkages, and Section 6 discusses the role of government, farmers and the private sector in implementing these strategies.

2. WHAT IS A SEED SYSTEM?

What do we mean by "seed" and "seed system"? Box 1 contains definitions for a number of the terms that will be used in this paper. Seed refers to the parts of agricultural plants that are used for sowing or planting purposes.[3] Several distinctive features of seed are worth noting. First, seed possesses a dual character that links both ends of the crop production process: it is both a means of production and (as grain) the product (Kloppenburg 1988). Second, seed has a synergistic relationship with other inputs such as fertilizer. The availability of quality seed can influence the adoption of other commercial agricultural inputs, and seed may require other inputs to realize its full genetic potential.[4] Third, seed varieties and complementary technologies need to be tailored specifically to agroecological zones, especially under rainfed conditions, requiring extensive plant breeding and agronomic research. Finally, since the yield advantage from improved seeds usually declines dramatically with late planting, timely access to seeds is crucial.

The term "seed system," as used in this paper and depicted in Figure 1, represents the entire complex of organizations, individuals and institutions associated with the development, multiplication, processing, storage, distribution and marketing of seeds in any given country. The seed system includes the traditional (or informal) system in which individual farm households carry out all seed functions for land races, including seed development, multiplication, processing and marketing,[5] and the non-traditional (or formal or commercial) systems comprised of specialized organizations with distinct roles in supplying seeds of new varieties. Seeds of new and landrace varieties flow from organizations and individuals in one stage of the "seed chain" to the next through channels depicted by arrows in Figure 1.

---

[3]Although vegetatively-propagated crops such as potatoes, cassava, and yams are important crops in SSA, most discussion in this paper focuses on cereal and legume crops propagated by true seed, which account for virtually all the activities of seed programs in developing countries (Cromwell, Friis-Hansen, and Turner 1992).

[4]For example, the yield potential of the improved wheat and rice seeds that triggered the Green Revolution in the 1960s and 1970s was realized only when seed was used in combination with other inputs such as chemical fertilizers, irrigation, pesticides, and improved crop management. Allan's 1968 study on the hybrid maize technology package in Western Kenya showed that yield and net returns per unit area were maximized only if all package elements were adopted simultaneously. However, with good husbandry, it was also profitable to use improved seed without fertilizer. Cromwell (1990) suggests that for cash-constrained smallholders it makes financial sense to adopt new seed with improved management alone. Fertilizer is usually the single most expensive component of the technology package, while seed costs represents only 5% of total variable costs per hectare for most smallholder food crops in Kenya (Ruigu 1988).

[5]According to Cromwell, Friis-Hansen, and Turner (1992), five key features distinguish informal from formal seed systems. Informal systems are traditional, semi-structured, operate at the individual community level, use a wide range of exchange mechanisms, and are able to deal with the small quantities of seed often demanded by farmers.

Box 1: Definition of Terms

Breeder seed. A class of seed in a seed certification program that (1) is produced under the supervision of the plant breeder, originator, or owner of the variety; (2) is controlled by that person or institution; and (3) is the source of initial and recurring increases of Foundation Seed.
Certified seed. A class of seed that has been certified to conform to the standards for genetic purity established and enforced by a seed certifying authority.
Foundation seed. A class of seed in a seed certification program that is the last step in the initial seed multiplications and is intended for the production of certified seed. Also known as basic seed.
Grain. Seed consumed directly or in processed form by humans or animals.
Hybrids. The first-generation seed of a single, double, or three-way cross of selected inbred lines produced under controlled pollination. The second generation or subsequent generations from such crosses are not regarded as hybrids. "Single", "double" and "three-way" cross refer to the number of parents a hybrid has: two parental lines for a single cross; two single crosses for a double cross; and a pure inbred male parent and single cross female parent for a three-way cross. Seed yield is highest from double crosses, intermediate for three-way crosses, and lowest for single crosses.
Improved or new variety. Varieties that are an outcome of crop improvement research.
Inbred lines. Usually uniform and true breeding germplasm created through repeated self-pollination which can be used (1) as parents of inbred seed products; or (2) as parents of hybrids.
Landraces. Varieties inherited by seed users with no known pedigree or linkages with formal breeding research and development efforts. Also known as local varieties.
Open-pollinated variety (OPV). Variety of a population that is heterogenous (i.e., not uniform) and not true breeding (i.e., progeny of a single plant have variable characteristics).
Plant variety protection. The legal protection provided to a breeder, originator, or owner of a variety to control its production and marketing. Used synonymously with "breeders' rights."
Purity - varietal or genetic. The purity with respect to variety as determined by a field inspection or laboratory tests.
Seed. Parts of agricultural, silvicultural, and horticultural plants used for sowing or planting purposes.
Seed chain. A sequence of linked seed supply functions and operations beginning with seed research and development and continuing through the several stages of seed multiplication, processing (drying, shelling, cleaning) storage, and marketing.
Seed enterprise. Any organization involved in seed growing, processing, storing, and marketing either directly or through contracts with others as a for-profit business activity.
Seed program. Activities being planned or implemented in a country to achieve the timely production and supply of seed of prescribed quality in the quantities needed.
Seed quality. Seed quality is determined by the seed genotype (genetic potential) and physical characteristics (e.g., size, shape, appearance, and moisture content), which are affected by harvesting, conditioning, treatment, storage, packaging and marketing practices.
Seed system. The entire complex of organizations, institutions, and individuals associated with the seed program of a country comprised of the **traditional or informal system** of farmer-selected, -multiplied, -processed, exchanged and retained seeds, and a **non-traditional or formal system** of individuals, organizations and institutions involved in specialized tasks related to producing and marketing seed for sale to seed users.
Seed users. Farm households or consumers who use seed for planting purposes.

Source: The definitions for many of these terms are adapted from Douglas 1980.

Legal institutions such as variety release procedures, intellectual property rights, certification programs, seed standards, contract laws, and law enforcement are also an important component of the seed system of any country (Figure 1). They help determine the quantity, quality, and cost of seeds passing through the seed system.

Seed products pass through the chain of activities to one of three outlets. They are either sold in the market, used in development programs, or retained by households for the next planting season (Figure 1). Seeds of landrace varieties and of new varieties that have entered the farmer-based informal system are generally retained by farm households for their own use or exchanged with other farm households. Seeds of new varieties entering the formal system of seed organizations are usually marketed, but some are also used in development programs, such as drought and disaster relief and the free distribution of seeds to promote new varieties.

As depicted in Figure 1, the three "supply targets" of the seed system – markets, non-market distribution and retained seeds – form the three sources of seed for seed users (i.e., farm households). The relative importance of each seed source will depend on the effective demand for seeds of new varieties compared to landrace varieties. Farmer retention is the most common source of landrace varieties for most grain crops. For new varieties, markets and farmer-retention are both important sources depending on whether the demand for seeds is continuous or periodic. Non-market sources of seed are important in cases where demand for seed is affected by chronic poverty or by external conditions (such as drought, war, disasters) affecting a region (discussed in greater detail in Section 4.2).

The illustration in Figure 1 provides a basic framework for understanding the concept of the seed system and how it is affected by the dynamics of seed demand. The illustration is generalized over crops and the economic status of countries. It is also simplistic, since it does not account for all the existing and possible linkages between different organizations that carry out supply functions in traditional and non-traditional systems. It nevertheless provides a basic framework for identifying gaps, opportunities and strategies for organizing and effective seed system. **A well-functioning seed system is defined as one that uses the appropriate combination of formal, informal, market and non-market channels to stimulate and efficiently meet farmers' evolving demand for quality seeds.** In the following section we review the current state of seed systems in Africa and the challenges facing policymakers and program administrators charged with developing and implementing strategies to improve the seed system.

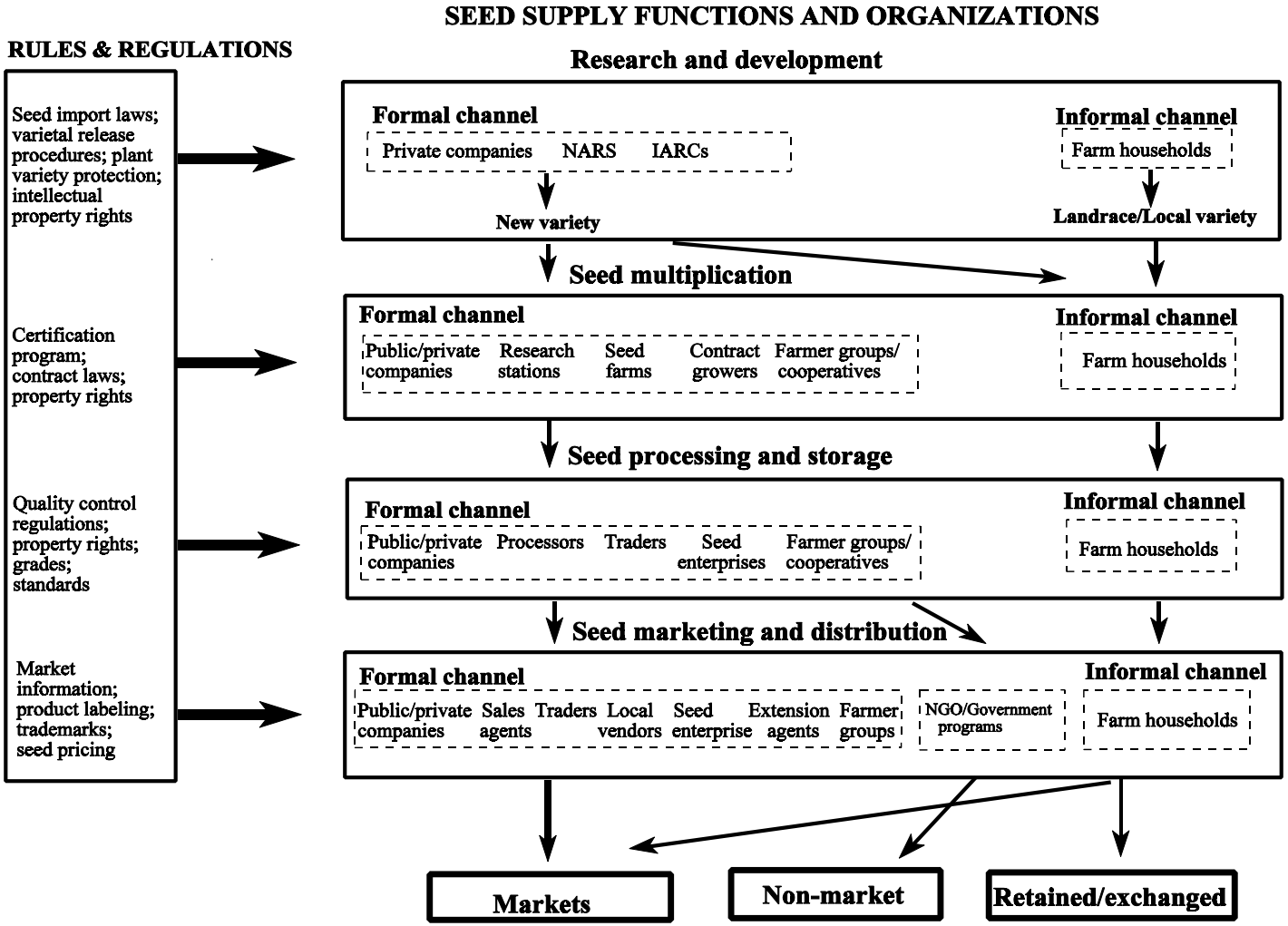


Figure 1. Seed System: An Organizational and Institutional Framework

3. SEED SYSTEMS IN AFRICA

3.1. Overview

African seed system development varies by country. At one end of the spectrum are countries that have only rudimentary breeding and testing programs for a few food crops and lack seed development strategies, seed policies, and quality control and certification procedures. At the other extreme are a few countries (e.g., Kenya, Zimbabwe) which have breeding programs for a wide range of crops and a comprehensive body of seed legislation (Venkatesan 1994).

In SSA overall, formal channels supply only 10% of total demand for seed, cover a limited range of crops (e.g., hybrid maize and sorghum) and serve a small group of elite farmers (Cromwell 1996, p. 20; Wright et al. 1994). Most smallholder crops (e.g., open-pollinated sorghum and millets, legumes) remain unserved by the formal system.[6] Farmer-based informal systems supply the majority of seed. Some 60-70% of seed used by smallholders is saved on-farm, and the other 20-30% is borrowed or purchased from neighbors, relatives, friends and other local sources[7] (Cromwell 1996).

Only about one-third of SSA countries have formal seed production and distribution facilities for major food crops (FAO 1994). Table 1 summarizes the results of an FAO survey that rated food seed systems in Africa, Asia, Central America/Canada and South America on the basis of varietal improvement, seed quality control, and seed production and distribution activities. Most African countries had pilot activities, but only one-fourth had advanced programs. The level of development was higher for food crops than other commodities. Many countries reported no efforts to control seed quality, production or distribution for industrial crops, for example, and vegetable and pasture crop seed development was weak across all regions.

The adoption of new seed varieties is also a crude measure of seed system status. As the seed system evolves, an increasing proportion of cultivated area is planted to new seed varieties which can better withstand biotic and abiotic stresses and respond to the use of other commercial inputs. Table 2 presents estimates of improved variety adoption for major food crops in SSA. The adoption rate for maize (43% of area) is comparable to levels in other developing regions. Since many improved maize varieties are hybrids sold by private seed companies, this suggests that formal seed systems are functioning relatively well for maize. Adoption of improved varieties of other food crops, e.g., sorghum and millets, still lags behind in Africa.

[6]For example, a recent survey of the bean seed sector in the Great Lakes region found that only one in 600 farmers procured seed through the formal system (Sperling, Scheidegger, and Buruchara 1996).

[7]Informal farmer-to-farmer seed exchange is extremely important in some countries. In Ethiopia, an estimated 25 to 50% of farm households borrow or buy seeds every year from neighbors and relatives (Henderson and Singh 1990). In Malawi, two-thirds of all bean seed is obtained from neighbors, relatives and other local sources (Cromwell and Zambezi 1993).

Table 1. Food Seed System Level of Development, by Region and Activity, 1989-90

Region/Function (number of countries)	Advanced Level (%)	Pilot Scale Operations (%)	No Activity Reported (%)
Variety Improvement			
Africa (27)	24	68	8
Asia (20)	50	35	15
Central America and Canada (12)	64	18	18
South America (10)	90	10	-
Seed Quality Control			
Africa (27)	25	63	12
Asia (20)	45	30	25
Central America and Canada (12)	48	35	17
South America[a] (10)	70	10	10
Seed Production and Distribution			
Africa (27)	34	60	6
Asia (20)	40	60	-
Central America and Canada (12)	49	43	8
South America (10)	90	10	-

Source: FAO 1994

[a]Figures reported in the source document do not add to 100%.

Table 2. Improved Variety Adoption in Sub-Saharan Africa

Crop	Region/ country	Area planted to improved varieties	Comments	Yield advantage	Key factors in yield advantage, adoption
Maize	Africa	43%	25% hybrids 17% OPVs Adoption comparable to other regions	30-40% for hybrids; 14-25% for OPVs	Resistance to streak virus
Wheat	Africa	52%	Mainly semi-dwarfs; compare to 75%+ adoption in other regions	10-25%	Short stature; disease resistance
Rice	West Africa	55%	Overall adoption less than other regions, but rates in some agroecological regions higher than Asia	35%	Improved post-harvest features
Sorghum	E. & S. Africa	3.5%	Reflects only varieties based on ICRISAT germplasm	50% for hybrids	Improved resistance to disease, insects
	West Africa:				
	Chad, Senegal, & Nigeria	25,000 to 50,000 ha	Breeders' estimates	30 to 40% for OPVs with normal rainfall	
	Mali	20-30%	Breeders' estimates		
Millet	E. & S. Africa	6%	Reflects only varieties based on ICRISAT germplasm	20%	Improved resistance to disease, insects
	West Africa:				
	Chad & Senegal	40,000 to 60,000 ha	Breeders' estimates		
Cowpeas	West Africa	NA		40%	Insect resistance
Potatoes	E. & C. African highlands	50%	–	40%	Disease resistance

Source: Maredia, Byerlee, and Pee 1999

Non-market channels (such as seed aid distributed through drought relief programs) have been the most important source of improved sorghum and millet varieties (Rohrbach and Mutiro 1996). Yield increases from the adoption of new seed varieties are potentially great (Table 2). Hybrid seeds typically have a 30 to 50% yield advantage over local open-pollinated varieties when complementary inputs such as fertilizer, irrigation and pesticides are used. Even without complementary inputs, new seeds of open- and self-pollinated crops have a 10 to 25% yield advantage over replanted traditional seeds on average. Productivity increases from the adoption of new seeds derive from on-going genetic improvements in disease and insect resistance, drought tolerance and post-harvest features. These increases can be substantial, especially if farmers continue to renew seed stocks and adopt new varieties. For example, gains from the periodic resupply of genetically improved wheat seed (among farmers who have already adopted improved varieties) are estimated to range from 0.5% per year in low rainfall conditions to 1.0% per year in irrigated regions (Byerlee and Moya 1993).

The challenge for administrators, seed program managers and policymakers is to ensure that the adoption of new seeds – through market or non-market sources – does not become a one-time event. Information such as the varietal age of seeds planted by farmers (an indicator of the frequency at which farmers replace new seeds) and methods used for harvesting, drying, treating and storing farmer-retained seeds of new varieties are critical indicators of the seed system's ability to resupply and maintain the quality of new seeds. In our view these indicators are as important as tracking the initial adoption of new varieties, but varietal age and seed conservation techniques are rarely monitored or analyzed in developing countries.[8]

In the next section we turn to a more in-depth analysis of different seed chain functions and how they are carried out in SSA. We examine seed research and development, multiplication, processing and distribution components.

3.2. Seed Chain Components in SSA: Description and Analysis

3.2.1. Seed Research and Development

In Africa, as in other developing regions, varietal development is dominated by public sector national agricultural research institutes (NARIs). International agricultural research centers (IARCs) play an important role in providing improved germplasm to NARIs, and breeders also collect and utilize locally adapted landraces.

Many research and development systems are biased towards crops and varieties demanded by the more commercial or elite farmers. Breeding and varietal release procedures followed by those NARIs may not lead to the development and availability of a broad enough range of varieties to meet the needs of all seed users, especially smallholder subsistence farmers (Tripp 1995a;

[8] Exceptions are studies by Brennan and Byerlee (1991), and Heisey (1990) on wheat varietal age and replacement.

Sperling, Scheidegger, and Buruchara 1996). For example, farmers in Zambia indicated that "wrong variety" was an important problem for all major crops, including maize, groundnuts, beans, sorghum, pearl millet, and bambara nuts (Ministry of Agriculture 1991).

There are several important issues. First, NARI plant breeding strategies often do not address the needs and demands of smaller, more subsistence-oriented farmers. For example, wide adaptability and high yield potential are frequently emphasized rather than the zone-specific adaptation that provides yield stability (Cromwell 1990). NARIs tend to select as "improved" the limited number of varieties that show a good yield response (with input use and good husbandry practices) across a range of different environments. One of the major findings of a case study in Kenya, however, was that adoption decisions of small farmers were more strongly influenced by factors other than yield, such as riskiness (drought resistance and time to maturity), taste, marketability, and susceptibility to field and storage pests (Johnson 1989).[9]

Second, there are often inconsistencies between the seed varieties preferred by smallholders and those actually supplied by seed production agencies. In Kenya, the potato varieties included in the official seed program were frequently not popular with farmers, and varieties which were popular among farmers were not in the seed production program (Crissman, Crissman, and Carli 1993). Similarly, Rwandan farmers gave a high rating to the bean cultivar RWR221, but it was not offered by the seed agency because of its susceptibility to rust in their low-lying, centralized multiplication plots – a problem that was rarely encountered in farmers' fields which tended to be on hill slopes (Sperling, Scheidegger, and Buruchara 1996).

Third, budgets for African research agencies have fallen dramatically in recent years following structural reforms and declining donor interest (Pardey, Roseboom, and Anderson 1991). This has affected the continuity and productivity of breeding programs and consequently the development and maintenance of improved varieties. The research and development sector has also been severely affected by political upheavals. Uganda released several regionally successful bean varieties in the 1960s, but commodity research programs collapsed during the 1979-86 political unrest and have regained momentum only recently (David 1994).

Private sector involvement in SSA seed systems has been limited by unfavorable policies and the uncertain political environment. In the early 1990s, Pioneer Hi-Bred International withdrew investments worth US$54 million in seed research, distribution and oilseed processing activities in Nigeria, Morocco, Ethiopia, Sudan, Egypt, Cote d'Ivoire, Zambia and Cameroon because of these problems (Theobald 1992; Pioneer Hi-Bred International 1993).

[9]Cromwell (1990) points to a clear distinction in the criteria used by subsistence-compared to more market-oriented farmers. In the Kenya case, the subsistence farmers wanted the new varieties to provide a wide range of attributes, including reduced yield variability between seasons, pest and disease resistance, taste, storage qualities, etc.– not just higher yield. In the post-Green Revolution areas of Pakistan, however, farmers changed varieties primarily to obtain higher yields (Heisey 1990).

3.2.2. Seed Multiplication, Processing, and Distribution

Once the formal research and development system develops a genetically improved variety, the task of the seed system is to multiply and produce quality seeds in bulk for users. Seed multiplication is primarily a management- rather than a capital-intensive activity. Within the formal system, multiplication of seeds is commonly a multi-generation process (from breeder to foundation to certified seed) undertaken over three to five years.

Seed multiplication activities can be organized in a number of ways. The options include vertically integrated seed company farms (private or public sector); contract growers, and smallholder seed bulking farms (Figure 1). There is no single correct and efficient way of organizing seed multiplication. The choice of organization will depend on local management capacity, the characteristics of the seed market, and the resulting cost implications. Seed company farms that carry out all stages of seed multiplication at a central large-scale facility can achieve significant scale and size economies. However, the feasibility of centralized seed multiplication depends on the cost of serving the market from one location. Public sector farms have often had problems maintaining control of quality and costs. Using contract growers to produce bulk amounts of foundation seed from certified seed is less management-intensive than running a centralized seed farm. It also permits better tailoring of the quantities produced to meet seed demand, and allows firms to shift some of the production and marketing risk to contract growers. These types of contract seed multiplication schemes are widely used in many African countries, often under NGO management. Contract seed multiplication does involve additional costs, e.g., regular supervision and seed inspection visits must be made over a much wider area, and growers must be paid premiums for seed production. However, we know of no studies comparing the relative cost-effectiveness of alternative seed multiplication strategies.

After seed is multiplied it goes through several processing steps. Contaminants and poor quality seed are discarded, and seed is sized, treated and packaged. These steps maintain the physical qualities of seed to enhance seed appearance and germination rate, deter seed-borne diseases, prevent insect infestation, and facilitate planting. In the informal seed system these steps are carried out by farm households using traditional techniques. Within the formal seed system, seed processing is a mechanized activity using specialized equipment, facilities, and products. Seed processing can be an in-house activity for many seed companies, or it can be carried out as a specialized activity by processors (Figure 1). The seed processing plant is usually one of the largest capital investments in a formal seed system.

In the formal seed system, seed distribution and marketing involves a number of linked functions, including logistical operations such as handling and transport, market research, promotional activities (such as field demonstrations), advertising, buying and selling functions associated with wholesaling and retailing, and the related facilitating functions of risk-bearing and financing (Jaffe and Srivastava 1992). Seed distribution and marketing can be carried out by any or all of the following: government agencies, private seed dealers, or local community-based organizations, including NGOs (Figure 1).
Seed system performance is often measured by the efficiency of seed distribution and marketing. This is because distribution connects all the previous stages of seed supply with seed demand,

reflecting both the strengths and weaknesses of linkages between various components of the seed chain. Seed distribution is also an activity that potential seed users can directly observe and compare with alternative formal and informal distribution systems. Over-centralization, poor management and high production costs are common problems in public seed distribution systems which often lead to losses, late delivery, deterioration in seed quality, and unmet seed demand in remote areas. Private sector seed distribution is often more efficient, but private firms usually confine their operations to commodities and areas where there is a strong and assured demand for seed and profits are likely to be greater.

Seed production costs are a function of crop biology, the size of the market and the organization of seed multiplication. Key considerations include:

- **Crop biology**. The low multiplication rate[10] for some crops (e.g., groundnuts) makes seed multiplication and distribution very expensive, particularly at centralized facilities. For example, 1 kg of groundnut breeder seed will yield less than 10 kg of seed after one generation, compared to a 1:100 kg multiplication ratio for maize breeder seed.

- **Size of the market**. Smallholders usually demand small quantities of a variety of seeds. This makes it more difficult for private companies to achieve economies of size and scale in seed production and distribution.

- **Organization of seed multiplication**. The technical demands of some types of seed multiplication and the certification process have encouraged centralization of multiplication activities. Firms focus on a few varieties to achieve economies of scale and size, but as a result the diverse needs of the wider group of seed users have not been met. In addition, certification requirements have effectively discouraged competition in the multiplication of improved varieties.

These factors will be discussed in greater depth in Section 4.

In summary, a major challenge facing SSA seed multiplication systems is to establish multiplication units that (1) are closer to the market; (2) can produce small quantities of seed for a number of different varieties and commodities; (3) have lower seed production costs; and (4) can produce good quality seed. The primary challenge for the distribution and marketing system is to make seed available to a range of seed users on time and at a low cost. Meeting these challenges will require integrating the commercial and development forces that drive formal seed systems with the versatility, elasticity and sustainability of traditional seed systems. Before we can derive strategies to address specific constraints, it is important to understand how seed systems develop. In the following section we describe the evolutionary stages of seed system development and begin to identify potential points for intervention.

[10]The net increase in the quantity of seed produced in one generation.

4. SEED SYSTEM TRANSFORMATION: A CONCEPTUAL FRAMEWORK

4.1. Stages in Seed System Transformation

The seed system passes through several phases as it evolves from a traditional system, where all production and supply functions are carried out by the farm household, to a more complex system in which many different organizations (e.g., seed companies, seed growers, farmer-based seed enterprises, seed processors) and legal institutions (e.g., seed standards, regulations, certification programs) play specialized roles in the seed supply chain (Douglas 1980; Pray and Ramaswami 1991; Jaffe and Srivastava 1992; Rusike and Eicher 1997). Table 3 presents a stylized representation of the seed system transformation process. The key features of each stage are summarized below.

- In **stage 1**, the informal seed system predominates; most farmers save their own seed or obtain seed from nearby farmers or villages, and the rate of new varietal development and adoption of new seeds is low.

- During **stage 2**, seeds of improved varieties developed by publicly-financed research begin to replace local varieties, use of complementary inputs (e.g., fertilizer) is limited but increasing, and an emerging private sector is involved in the multiplication and distribution of public varieties.

- During **stage 3**, the private sector begins to play an active role in research and development, particularly in developing hybrids and seeds for specialized cash crops. Seed distribution systems become more organizationally varied and decentralized, and many components of the mature seed system exist but the supply of seed from the formal sector still ranges from fair to poor.

- In **stage 4**, the seed system and the agricultural sector as a whole are well developed. Commercial seed production and marketing are common, effective seed laws and regulations are in place, linkages with actors outside the seed sector are well established, and the use of improved seed is widespread. Box 2 provides a brief overview of the U.S. seed system as an example of a stage 4 seed system.

As the seed system evolves, advancements in plant breeding and seed processing methods make it possible to expand seed research, production, multiplication, processing and marketing functions beyond individual farmers and communities. The rules, regulations, and infrastructure coordinating the components of the seed system also evolve to allow organizations to specialize in different functions of the seed system. The public sector may specialize in basic research and research on subsistence crops, and in regulating the seed system, for example. The national and international private sectors increasingly focus on research, production and marketing of seed for hybrids, specialty crops, vegetable crops, and commercial food and fiber crops.

Table 3. Stages in Seed System Transformation

	Stage 1 *Farmer Selection and Supply*	*Stage 2* *Introduction of Improved Varieties*	*Stage 3* *Widespread Use of Improved Public Varieties and Early Spread of Private Varieties*	*Stage 4* *Advanced Seed System*
TECHNIQUES				
Seed Research and development:				
a. Varietal Development	Farmers experiment; Mass selection	Public crop breeding research; Testing of foreign varieties	Generic seeds; Both public and private firms produce new varieties and hybrids	a. Proprietary seeds; Private sector produces most new varieties; Public sector does basic research and development, self-pollinated and minor crops
b. Seed Technology	On-farm seed processing and storage using traditional methods	Seeds of new varieties processed and stored using special techniques at public facilities	Seed processing and storage are increasingly sophisticated; These activities, and seed packaging and marketing, are increasingly dominated by the private sector.	b. Seed processing, storage, packaging and marketing technologies are as important as varietal improvement; All seeds used (purchased and retained) undergo rigorous and careful treatment, conditioning, and packaging
Seed Production	By farmers; Little or no distinction between seed and crop production	Breeders' seed is produced by public research and development organizations; Basic seed produced by government farms or farmers; Commercial seed produced by government farms, contract growers or farmers	Shared roles for public and private research and development organizations in production of breeders' seed; Private firms increasingly involved in basic and certified seed production	Breeders' seed, basic seed and commercial seed produced by private firms and farmer cooperatives
ENVIRONMENT				
Marketing and Distribution	Farmers' seed is locally traded; Seed quality is uncertain	Distribution by farmers and public and private firms; Pervasive uncertainty about seed supply and demand	Public and private firms distribute, with the share of private firms increasing; Demand uncertain; Finance difficult to obtain and risky	Distribution by private companies and farmer cooperatives
Governing Institutions	Informal habits, custom	Political system capable of enforcing property ownership rights	Political system capable of enforcing plant breeders' rights; Contract law; Trade secrets laws; Quality control regulations; Quarantine laws	Political system capable of enforcing intellectual property rights; Plant patent law and trademarks
Seed Prices	Gifts or in-kind trades	Close to grain prices	Private varieties have higher prices	Private varieties have higher prices
Signaling	Farmer-to-farmer reputation	Government seed certification label	Certification label and private brand names; Seed company reputation	Strong proprietary product differentiation with strong reputation effects
COORDINATION				
Information about new varieties	Other farmers	Extension service	Other farmers; Extension service; Private advertising	Extension service; Private advertising
Availability of complementary inputs	Very limited amounts of fertilizer, some irrigation	Some irrigation; Fertilizers, some pesticides available through government channels but distribution extremely limited	Fertilizers and other agricultural chemicals available	Fertilizers and other agricultural chemicals available
PERFORMANCE INDICATORS				
Seed productivity	Low	Moderate	High	Continually increasing
New variety development	Low	Moderate, erratic	High, more stable	High, predictable
Adoption/Diffusion rate	Low	Moderate, erratic	Moderate, rapid	High, rapid

Source: Adapted from Rusike 1995; Pray and Ramaswami 1991

Box 2. The U.S. Seed System: An Example of the Advanced Phase of Seed System Development

The structure of the formal seed system in the United States is unique. While there is a mix of public and private sector activities in varietal development, most of the seed production and virtually all of the quality control and distribution activities are undertaken by private companies.

The United States is the world's largest producer and consumer of commercial seeds, an industry valued at $4.4 billion. Agriculture is advanced, large-scale, commercially oriented and diverse. The most advanced segments of the U.S. seed industry are hybrid field crops, vegetables, forage, ornamental and forest crops – 100% of which are supplied by the formal supply system. Yet wheat and soybean, also major crops, have seed replacement rates of less than 30% and 50%, respectively. Seed replacement for cotton varies from nearly 100% in irrigated regions of the West and upland cotton areas in South to less than 50% in the high plains of Texas, where yields are low and farmers minimize costs by cleaning and treating saved seed for planting.

Within the public sector, the U.S. Department of Agriculture, the State Agricultural Experiment Stations, and the land-grant universities play a major role in collecting germplasm and carrying out basic research and varietal development. Public varieties are still dominant for several self-pollinated crops where most farmers plant retained seed. Even with the enactment of stronger legal protection for plant breeders' products, the private sector has directed little investment toward these crops.

Private sector firms active in commercial seed production and trade are extremely diverse. A few firms are large in size and engage in a range of research and development, seed production and marketing activities. Many firms have multinational and multi-sectoral interests. Another group of firms is engaged in seed multiplication, processing, and distribution, but not research and development. A few companies also develop new varieties and supply parent materials to other seed companies. Many firms are crop-specific and cater to a specific agroecological region. Some of them acquire licenses to produce specific varieties and also offer public varieties. Individual certified seed growers multiply and distribute public varieties, and a large number of farmers (called brown-baggers) multiply and sell truthfully labeled seed of self-pollinated crops.

Source: Srivastava and Jaffee 1993

Community-based organizations and NGOs try to fill the gap by concentrating on multiplication and distribution of seed for crops and farmers not targeted by the private sector.

The transformation process described above should not be interpreted as the simple linear progression of a national seed system from an informal to a formal system (Tripp 1995b). Seed systems for different commodities follow distinct development paths as they move from one phase to the next. For example, the path for a hybrid maize seed system will be different from that for millet or cowpea, and those systems may never reach the technical, organizational and institutional complexity of a hybrid maize seed system in phase 4. The seed system for maize in the advanced phase (such as in the U.S.) may be composed only of formal seed channels, with the private sector meeting the market demand for hybrid seed each season. On the other hand, seed systems for beans, wheat, cowpeas, and groundnuts, even in a mature phase, may have all the components of the seed system depicted in Figure 1, with both formal and informal sectors playing important roles in meeting the demand for seed.

We join other authors in stressing the complexity and diversity of the seed sector in each phase and the dynamic roles of a range of formal and informal seed organizations in promoting the transformation process (Tripp 1995b; Louwaars 1994). Two points are particularly important: (1) the **changing** (but not necessarily declining) public sector role as private sector involvement increases in different stages of the seed chain; and (2) the **declining** (but not necessarily absolute) importance of the informal seed system as the seed system develops. Past donor and government strategies were based on a much narrower interpretation of the transformation process, focusing only on the development of large-scale public and private commercial seed enterprises and regulatory agencies that promoted the use of certified seeds and hybrids.

Taking the broader perspective of the seed system transformation process (illustrated in Table 3), we argue that promoting seed system transformation in economies that are at the initial phases will require increased emphasis on strengthening farmer/community-based and other small private seed organizations. The government must play a continuing role in supporting seed system development to assure that the demand for improved seeds from diverse clients is met.

4.2. Seed Demand and Supply Dynamics

Seed system development can be viewed as a dynamic process of matching the supply to the changing demand for seeds. On the supply side, this involves strengthening and promoting the seed supply organizations depicted in Figure 1 and described in the preceding section. It also involves designing institutions (e.g., seed regulations governing varietal development, release, and certification) appropriate to existing technical (e.g., type of crop, cropping system) and environmental (e.g., transportation, market infrastructure) conditions to promote the development of appropriate seed supply chains.

On the demand side, institutions and programs will influence farmer decisions regarding the use of saved versus commercial seed. Several factors affect this decision, including: (1) the farmer's ability to produce and save seed; (2) the type of crop (self-pollinated, open-pollinated, roots and tubers); (3) the yield or quality advantage of purchased seed; (4) the cost of seed (purchase price plus the cost of procuring seeds from distribution outlets); (5) the price and availability of complementary inputs; (6) the relative price of crops; and (7) the farmer's forecast of weather conditions and output prices (Pray and Ramaswami 1991).

These factors help determine the quantities demanded by farmers from market versus retained sources. The comparative advantage that different types of seed supply organizations will have in meeting these demands depends on three factors: the economic status of seed users; crop biology (e.g., breeding system, multiplication factor, seeding rate); and the market outlook for the commodity. In the next section we analyze the economics of seed supply organizations in relation to these demand factors.

4.2.1. Categories of Seed Users and Seed Demand

Three main categories of seed users can be identified in Sub-Saharan Africa:

- The first category of farmers are those who rely heavily on the formal seed system for their seed consumption. These are large- and medium-scale commercial farmers, usually located in high potential areas with good market infrastructure, whose main operational objective is to maximize marketable surpluses.

- The second category is made up of farmers who rely heavily on retained seeds and informal farmer-to-farmer seed exchanges. These are small-scale farmers whose primary goal is satisfying domestic consumption needs but who may also produce for the market.

- The third category is composed of seed-insecure farmers who are forced to consume all or a major portion of their harvests because of severe household economic conditions or external factors (e.g., drought, flooding, disease/insect infestation, war). This group may sometimes include category 2 farmers, since many subsistence farmers (especially those in marginal and high risk areas) transit between seed-secure and seed-insecure states depending on external factors.

Formal seed systems have largely served the needs of commercial seed users in category one. This is numerically the smallest group, but because of their buying power and political ties they have historically exerted a strong influence on plant breeding priorities and commercial seed development in Africa.[11]

The second and third categories constitute the majority of seed users in developing countries. In Africa the second category includes more than 60 million farmers, at least half of the total farming population (Cromwell, Friis-Hansen, and Turner 1992). The informal seed system is the major source of seed supply for these groups. Because many seed users have limited cash resources, are located in areas of limited agricultural potential remote from market infrastructure, and grow mainly subsistence crops, they are not very attractive to the private sector and public sector seed organizations have not been effective in supplying seeds to these groups.

Farmers in the third category can be divided into two groups: (a) farmers who are unable to use seeds saved from their own production or through exchange because of chronic **household** economic problems; and (b) farmers who are temporarily seed-insecure because of severe **external** conditions such as drought, flood, war. The needs of the temporarily seed-insecure are frequently met through free seed distributions by government- or donor-sponsored drought relief programs.

[11]The most well-known products of this influence are the hybrid maize varieties which emerged from breeding work undertaken in Kenya and Zimbabwe in the 1950s and 1960s (Gerhart 1974; Rusike and Donovan 1995; Rusike and Eicher 1997).

However, there are no special programs to serve those who are chronically short of seed. These farmers are forced to supplement their seed stocks by purchasing seed from the market. This category of seed users "turn(s) upside down the stereotype about market-orientation: the poorer the farmer, the larger is the proportion of his/her seed bought" (Sperling, Scheidegger, and Buruchara 1996, p. i).[12] The nature of the demand for seed by this group of farmers, however, is quantitatively and qualitatively different than the demand by farmers in category one (commercial farmers). While commercial farmers use markets to purchase select genetic materials, the chronically seed-insecure farmers are forced to accept any genetic material they can afford (Sperling, Scheidegger, and Buruchara 1996).

Two points about the differences in seed demand among these groups are worth emphasizing because they have implications for the relative importance of different seed supply organizations. The first is the diversity in seed characteristics valued by different groups of seed users. Large- and medium-scale commercial farmers (category 1) use markets to purchase genetic materials that are highly responsive to chemical inputs and embody specific characteristics rewarded by the market. Subsistence-oriented smallholder farmers (category 2) are more interested in characteristics such as storage quality, taste, and resistance to pests (CIAT 1982; Johnson 1989; and Dougnac and Kokwe 1988 as cited in Cromwell, Friis-Hansen, and Turner 1992). Tripp notes that "...this argues for more local involvement of (smallholder) farmers in the varietal selection and seed production process, and less emphasis on the usual release criteria of distinctness, uniformity and stability..." (1994, p. 17). The stringent release criteria become important only in the latter phases of the transformation process as more farmers become commercial producers.

The second point is the diversity in the quantity, variety and frequency of seed demanded by different groups of seed users. Because of their small landholdings, practice of mixed cropping, and strategy of minimizing production risks by diversifying the variety base, smallholders require relatively small quantities of seed, for different varieties of the same crop. They also recycle seed over more seasons than larger commercial farmers. Smallholders rarely plant all of their crop area with purchased new seeds. Instead they may purchase small quantities and multiply enough seeds to meet their requirements for the following season. Surveys in Zambia, Burundi and Malawi indicate that farmers typically want 5 to 16 kg of maize, bean and groundnut seed per household (Sperling 1993; Friis-Hansen 1992; Cromwell and Zambezi 1993). This is far below the standard pack sizes available through conventional seed marketing schemes.[13]

---

[12]This observation by Sperling, Scheidegger, and Buruchara (1996) was based on bean seed systems in the Great Lakes. However, this relationship between farmers' economic status and dependence on seed purchases may not hold true in all regions and for all crops. For example, David (1994) found that only few bean farmers in her sample of two regions in Uganda were chronically seed deficient.

[13]Some analysts argue that although improved seed itself is a relatively scale-neutral innovation (i.e., not biased to any particular group of seed users), because of the way they are marketed (e.g., large packet size and limited availability) and because of the factor bias of some improved varieties (i.e., some need more external inputs to realize their full potential), smallholders may be relatively disadvantaged in making use of the complete seed technology package (Cromwell, Friis-Hansen, and Turner 1992).

4.2.2. Seed Biology and the Profitability of Seed Production

Biological and technical characteristics of crops affect the potential profitability of seed production and marketing for formal sector firms and the importance of formal vs. informal organizations in the seed supply chain for a particular commodity. A description of the most important characteristics is presented in Table 4. They include the seed production method, sowing rate, multiplication factor, rate of deterioration, and the frequency of purchase (Cromwell, Friis-Hansen, and Turner 1992). Table 5 summarizes how these biological characteristics affect the potential profitability of seed production and marketing for commercial firms.

In general, commercial interest in seed production varies with the technical possibility of excluding non-buyers from using the products of the firm's research (Table 5). Production costs follow a similar continuum, increasing with the complexity of the seed production technology. Since there is very little erosion in the yield potential with successive planting of self-pollinated crops such as wheat, rice, and groundnuts, farmers can reproduce the purchased seed themselves for future planting. Thus there is little commercial incentive to produce and market improved seed of self-pollinated crops beyond supplying the initial demand for new varieties. Informal seed systems predominate for self-pollinated crops worldwide among subsistence and highly commercialized farmers.[14]

For cross-pollinated crops such as maize, sorghum and millet, both formal and informal seed systems are important. Formal systems of seed supply are important because varieties become contaminated: the yield potential of successive generations is reduced unless the seeds are renewed occasionally. Cross-pollinated crops thus have greater recurrent sales potential than self-pollinated species. Commercial production of improved OPVs requires controlled pollination and special care to avoid contamination. Investments in labor and management increase the production cost of OPV seed relative to grain. The higher price of OPV seed motivates farmers to recycle their purchased OPV seed for more seasons, which reduces profits and discourages formal sector involvement. Commercial seed companies, instead, tend to promote the development and use of hybrid seeds of cross-pollinated crops. Hybrid seed technology offers the perfect technical means for preventing non-buyers from using seed technology since hybrid yields deteriorate sharply when they are replanted. Commercial interest in producing and marketing hybrid seed is very high. Hybrids usually have a higher yield potential but are more costly to produce than OPVs and may be priced beyond the reach of cash-constrained small farmers.

Another characteristic that affects the relative importance of formal and informal systems is the multiplication rate. Crops with a high multiplication factor (such as maize, sorghum and millet) are easier for the formal seed sector to handle. Fewer multiplications are required to obtain a targeted amount of seed and, at each stage, there are smaller quantities to process, store and

[14] For example, in the U.S., where most seed users are commercial farmers, more than 75% of seed planted for wheat, oats and rye, and one-half of the volume of seed used for soybean, groundnut and barley production is farmer-retained (Venkatesan 1994).

distribute. Farmers also require a relatively small amount of seed per hectare and subsequently seed cost usually represents a small proportion of total production costs per hectare. Formal sector firms can get away with increasing the unit price of seeds with high multiplication factors, as is evident from the grain to seed price ratios reviewed in Table 4.

On the other hand, grain legumes are characterized by low multiplication factors and high seeding rates, and these are consequently the least attractive crops for commercial seed companies. The extreme example is groundnut, a self-pollinated crop with a multiplication factor less than 10 and a sowing rate of 125 kg per hectare (Table 4). The most economical way of producing groundnut seed would be to multiply and sell it locally to neighboring farmers without bagging or certification.

The relative importance of formal and informal systems of seed supply will also depend on the availability of new varieties with significant yield and/or quality advantages. Recurrent sales of improved seed depend partly on the ability of the formal research and development system to provide a steady flow of new varieties to maintain farmer interest. In addition, the rate at which new varieties succumb to biotic stresses both in the field and during on-farm storage helps determine the level and frequency of purchases from the formal seed system by farmers. For example, wheat and rice are particularly susceptible to insect and disease pests, creating a demand for pest-resistant varieties as they are released from research systems.

The dominance of various seed supply organizations is also determined by the product market situation, i.e., whether the crop is for the commercial market or subsistence consumption. The degree of commercialization determines the nature of demand for seed (e.g., the quantity, characteristics and frequency of seed demand) and also influences the relative attractiveness of seed production to different types of organizations. In general, private seed organizations will be more interested in supplying seeds for crops that can provide a relatively secure and predictable market than for subsistence crops whose seed demands are unpredictable.

There are other means – legal and policy – which can increase commercial interest in research and marketing of seeds (Table 5). For example, plant variety protection laws that prevent other commercial seed producers from marketing seed without a license can provide an incentive for private sector research. Similarly, improving access to local and imported germplasm can encourage commercial enterprises to produce and market improved seeds of self- and open-pollinated crops.

Table 4. Biological Characteristics of Seed Products of Major Crop Species

	Hybrid Maize	Open Pollinated Maize	Open Pollinated Sorghum/Millet	Wheat	Rice	Beans	Groundnuts
Seed Production Type	Controlled hybridization	No pollination (control with isolation)	No pollination (control with isolation)	No pollination (control with isolation)	Self Pollination	Self Pollination	Self Pollination
Sowing Rate (Kg/ha)	Medium 20 kg	Medium 20 kg	Low 10 kg	High 100 kg	High 125 kg	High 100 kg	High 125 kg
Multiplication Factor[a]	High	High	High	Low	Medium	Medium	Very low
Grain/Seed Price Ratio[b]	1:5 (single cross) 1:3 (three way cross) 1:2 (double cross)	NA	NA	1:2	1:2	NA	1:2
Frequency of Purchase	Annual	2 years	3 years	4 years	4 years	Variable	Variable
Sectoral & Economic Implications	-Formal system most suitable -Private firms may focus on serving commercial small-scale, medium and large-scale users	-Both formal and informal systems are important -Commercialization may be slow due to infrequent seed purchases	-High multiplication rate implies good potential for commercialization, limited somewhat by infrequent seed purchases	-Low incentive to purchase unless new seed quality distinctly superior to retained seeds -Seed demand now met through own production or informal sector -Role for public sector to provide improved varieties	-Low incentive to purchase unless new seed quality distinctly superior to retained seeds -Seed demand now met through own production or informal sector -Role for public sector to provide improved varieties	-Currently low incentive to purchase unless improved seed quality higher than retained seed -Demand now met through own production or informal sector	-Currently very low incentive to purchase -High seeding rate may attract small-scale private enterprise in the future -Demand now met through own production or informal sector

Source: Adapted from Cromwell 1996

[a] The multiplication factor is the net increase in seed quantity produced in one generation. Commodities with high multiplication factors require fewer generations to produce seed in usable quantities and are more attractive to formal sector seed organizations.

[b] Lower ratios imply higher seed production costs.

Table 5. Continuum of Seed Products and Commercial Interest in Seed Supply

	Local varieties/land races	Improved self-pollinated varieties	Improved OPVs	Hybrids
Seed production technology	Selected and maintained by farmers	Similar to normal grain production, with improved agronomic practices to control quality	Controlled pollination; seed produced in isolation to prevent contamination	Selective crossing of inbred lines; controlled pollination between selected male and female parents; isolated seed field
Seed production cost	Marginally more than grain production cost	Relatively more than grain production cost	Moderately more than grain production cost	Substantially more than grain production cost
Source of seed production cost	Selecting, drying, storing	Seed quality control	Labor and management cost of controlled pollination	Time cost in identifying and developing inbred lines; labor and management cost of controlled pollination and seed quality control; low net seed yields
Source of commercial demand for seed	None	New varieties with attractive characteristics; breakdown of pest resistance over time	New varieties with attractive characteristics; gradual yield reduction due to contamination in field	Decrease in hybrid vigor with each successive generation
Incentive for commercial seed supply	None	Very little	Moderate	High
Measures that may increase commercial interest in: **– Research and development**		Legal protection to prevent other commercial seed producers from marketing without a license (e.g., plant variety protection laws)	Legal protection to prevent other commercial seed producers from marketing without a license (e.g., plant variety protection laws)	Reduction of competition from the public sector
– Seed production and marketing		Easier access to improved varieties (e.g., from local public sources or imported public/private)	Easier access to improved varieties (e.g., from local public sources or imported public/private)	Deregulated seed markets

4.2.3. Seed Demand Factors and Supply Responses from Different Organizations

The diversity among seed users, in seed biological characteristics, and in the potential for commercialization implies the need for a diverse set of seed supply organizations. The seed supply system can be conceptualized as a continuum of seed organizations ranging from formal large-scale, multinational seed corporations to parastatal seed companies, NGO-supported seed networks, informal farmer seed exchanges and farmer-retained seed. Any one organization will not meet all seed demand, but together they can meet the needs of various users for different types of seeds. Public, private and non-governmental organizations have distinct comparative advantages in performing various activities within the seed chain and in supplying seeds of different types and commercial potential to various categories of seed users. The supply responses from different organizations to the demand factors and characteristics discussed in the previous section are summarized in Table 6.

The commercial sector is interested in profits. Its focus will be on those types of seed for which there is effective demand, a predictable market in terms of volume and frequency, and which are profitable, such as hybrids and other commodities requiring regular purchase of seed (Table 6). Public sector seed organizations usually have a mandate to serve a broad range of seed users, particularly those less able to buy seeds from commercial dealers. They may offer a wide range of seed types, including those that are relatively costly to produce (e.g., seeds with low multiplication rates such as groundnuts) and/or which have a relatively low value (e.g., self-pollinated crops such as beans, rice, etc.). They may also need to deliver emergency supplies to seed-insecure farmers in remote and marginal areas.

Farmer cooperatives, NGO seed networks and individual producers supply seeds of cross- and self-pollinated crops to subsistence and seed-insecure farmers. However, the most important source of seed for subsistence smallholders is farmer-to-farmer seed exchange and farmer-retained seed.

African seed supply organizations have not been able to effectively meet the needs in all the niche markets identified in Table 6. Unfortunately, substantial effort and resources have been spent in the past trying to replace the informal with a public sector-dominated formal system, rather than recognizing the strengths and defining the roles of a range of formal and informal seed organizations within the seed system.

Table 6. Supply Responses to Types and Sources of Seed Demand

Demand	Characteristics of Demand		Supply Response
Demand by Seed Use Types	Effective Demand	Frequency of purchase	
Poverty alleviation	No	Seasonal/periodic	Non-market solutions, possibly markets (e.g., seed vouchers)
Emergency program	No	Periodic	Non-market solutions (e.g., government, NGOs)
Renewal of variety	Yes	Periodic	Market (small-scale enterprises), non-market (free distribution of samples), farmer retention
Commercialization	Yes	Seasonal	Commercial large-scale enterprises
Demand by Seed Technology Types	Volume	Frequency of purchase	
Hybrids	High/ low[a]	Seasonal	Commercial large-scale enterprises
OPVS			
– High sowing rate (e.g., maize)	High	Periodic	Small-scale commercial enterprises
– Low sowing rate (e.g., sorghum, millet)	Low	Periodic	Government, NGOs, markets
Self-pollinated (Inbred lines)			
– High sowing rate (e.g., groundnut)	High	Rare	Small-scale commercial enterprises
– Low sowing rate (e.g., rice, wheat)	Low	Rare	Government, NGOs, markets
Special seed characteristics (e.g., difficult to store, disease risks, forage crops)	High/ low	Seasonal	Commercial enterprises

Source: Adapted from Tripp 1997

[a]The hybrid seed market is attractive to private enterprise because farmers must purchase seed annually; whether high or low volumes are purchased is less important.

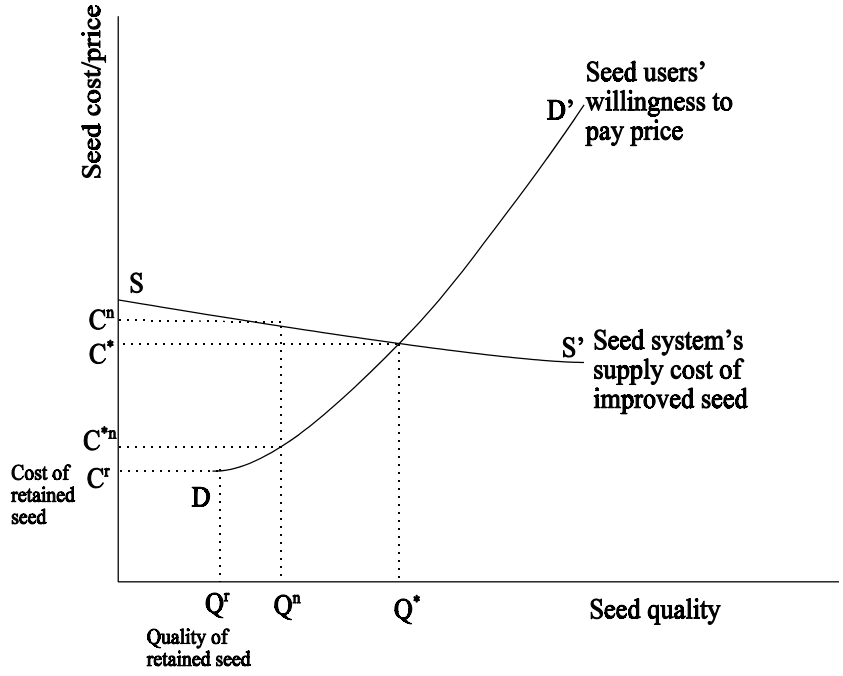
5. STRATEGIES TO PROMOTE SEED DEMAND AND SUPPLY LINKAGES

The challenge facing policymakers and administrators is to efficiently link the formal and informal organizations that make up the seed supply system to supply both market and non-market demand for seed. To derive strategies that promote linkages between seed demand and supply, we first conceptualize the demand and supply of new seed as a function of the quality (both genetic and physical) of new seed and the cost of supplying it through formal channels (Figure 2).[15]

New seed supplied by the formal system costs more to produce than farmer-retained seed. Formal sector costs include charges for research and development, seed multiplication, quality control, transportation, and establishing coordination mechanisms to vertically link the supply functions of the seed chain. The cost of new seeds supplied by the seed system is depicted in Figure 2 by the line SS′, and is higher than the cost of retained seeds, C^r. We assume that the new seed is of better quality (reflected in higher yields, pest resistance, and/or other desirable characteristics) than the retained seed. SS′ declines because we assume that the cost of supplying new seeds decreases with improvements in seed quality, i.e., higher yields will generally mean lower costs of seed multiplication.

[15]The analytical framework of supply and demand conceptualized here is different from the standard representation of demand and supply as functions of price and quantity. The standard representation conceptualizes the response of quantity demanded and supplied of a product to changes in its own price, holding constant the money income and price of other goods in the case of the demand curve, and the input costs in the case of the supply curve. Thus, in the standard analysis, the quantity demanded decreases with the price, and quantity supplied increases with the price of a given product. In this analysis, the demand for seed is conceptualized as a simple "yes" or "no" decision problem faced by seed users: whether to purchase quantity *x* of improved seed or use *x* quantity of retained seeds from the previous harvest. The user response is depicted in Figure 2. The seed user is willing to pay more for improved seed when the marginal cost is compensated by an increase in seed quality, such that the net return from using *x* quantity of improved seeds is at least equal to the net return from using *x* quantity of retained seeds. This willingness to pay price is compared with the cost charged by the formal seed system for improved varieties. In reality, decisions faced by seed users are multi-dimensional and include the quantity of seeds (ranging from 0...x) and the frequency of purchase, both of which affect the cost and ability of the seed system to supply seeds of improved varieties. Theoretical and empirical analyses of the demand and supply of improved seeds, incorporating the various complexities of seed and the seed system, are generally lacking in the literature. A few studies have analyzed the demand for improved seed as a single-period portfolio allocation problem between traditional and improved varieties (Herath, Hardakar, and Anderson 1986); as affected by the adoption of complementary inputs (Feder 1982); and as a long-term decision making problem, involving the demand for replacement seed and the optimal frequency of seed purchase (Heisey and Brennan 1991). The latter study provides an analytical model of the demand for replacement seed and an excellent discussion on the factors determining farmers' demand for replacement seed.

Figure 2. Seed Users' Willingness to Pay (Seed Demand) and the Seed System's Supply Cost in Relation to Seed Quality



The effective demand for new seed from market sources will depend on seed users' willingness to pay for the higher cost of the new seed, which is sensitive to both seed quality and price. As illustrated in Figure 2, seed users' willingness to pay a higher price (cost) for a new seed, DD′, increases with the quality of seed supplied by the seed system, since better quality seed translates into greater production or a higher price premium for the output. Since seed users have the option of using retained seeds of quality Q^r at a cost of C^r, the seed system must supply new seed which is clearly superior in quality to retained seed to induce seed users to purchase seed at a higher price not exceeding C^*. Given the cost structure shown in Figure 2, the new seed supplied by the seed system must be of quality Q^* or higher to motivate farmers to incur costs higher than C^r but not exceeding C^*. There will be no market demand for new seed of lower quality (Q^n) since seed users would rather use retained seeds than pay the price at which the seed system is able to supply the seed (C^n), since it is higher than their willingness to pay (C^{n*}) (Figure 2).

Different strategic responses are possible to promote linkages between the supply and demand for new seed. These can be divided into three broad groups:

- **Supplying better quality seeds**. As shown in Figure 3A, seed users will be willing to purchase new seed if the quality of new seed Q^n is at least of level Q*;

- **Lowering the cost of supplying new seeds**. Figure 3B shows that given the quality of new seeds Q^n seed users will be willing to purchase new seeds if the cost/price declines from C^* to C^{n*}. This involves shifting the supply curve SS′ to SS′′; and

- **Increasing seed users' willingness to pay for new seeds**. One strategy to link the demand and supply scenarios (shown in Figure 3C) is to shift the seed users' willingness to pay upward from DD′ to DD′′. Potential policy and program actions corresponding to each of these strategies will be discussed in the next section.

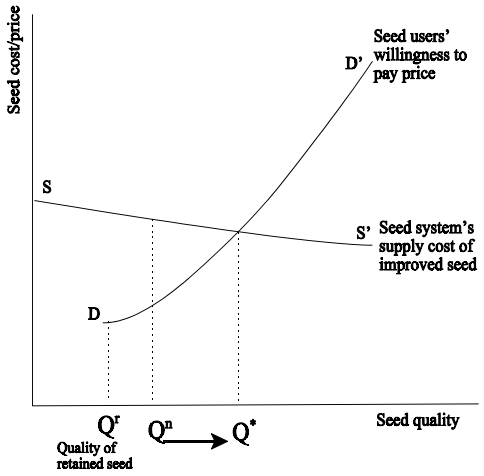
5.1. Strategies to Enhance the Quality of Seeds Supplied

Strategies to improve seed quality must begin with strengthening the public agricultural research and development sector on a long-term, sustainable basis. Developing new varieties that have significant yield/quality advantages over traditional varieties is important to offset the increased costs incurred by farmers in purchasing seed and/or other inputs. Successful examples of such varieties include the semi-dwarf wheat and rice varieties that triggered the Asian Green Revolution, flint hybrid maize in Malawi, CSH-1 hybrid sorghum, and the MBH variety of pearl millet in India. These new varieties yielded significantly more than traditional varieties, making it profitable for farmers to purchase and use the new seed.

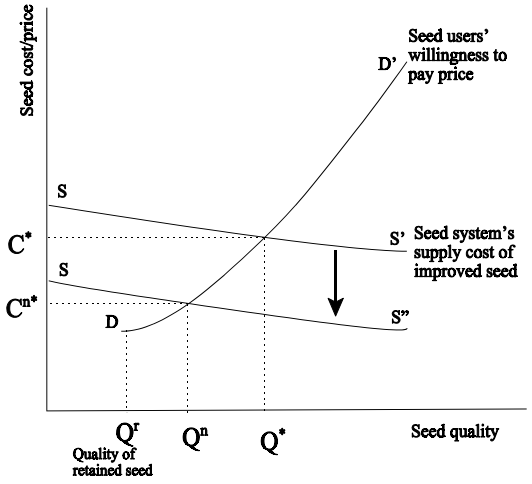
The challenge for the agricultural research and development sector is not only to develop new varieties to replace traditional varieties, but to continue to supply improved and better quality varieties over time to offset the genetic decline caused by the evolution of biotic stresses. Some authors suggest that society may place a higher value on avoiding a disease outbreak than individual users. If so, it may be in society's interest to promote rapid varietal replacement by subsidizing the costs of developing better quality varieties to avoid mass infestations and food shortages (Heisey and Brennan 1991).

Developing linkages with international and other national research and development centers, identifying promising germplasm, and conducting multi-location trials to generate information on the performance of germplasm in different environments are critical activities to strengthen the national research and development sector's ability to develop improved varieties. It will be especially important to build the capacity to move from homogeneous seed recommendations to the development and dissemination of varieties targeted to specific agroecological zones and groups of farmers. To facilitate this process, target groups should be defined more precisely, zoning of breeding plots and field trials should be improved, and management incentive systems should be developed to reward researchers and extension agents when new technology is adopted by target groups.

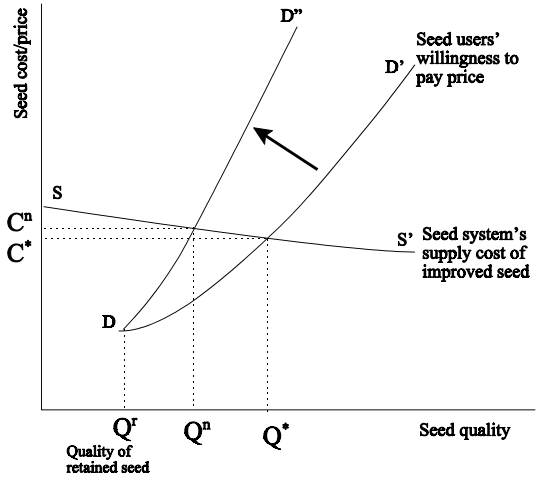
Figure 3. Strategic Alternatives for Linking the Demand and Supply of Improved Varieties



A. Improving the quality of improved seed



B. Lowering the supply cost



C. Increasing the demand for improved seed

Even with the measures described above, there will be cases where new seed quality is better than farmer-retained seeds of specific crops, but is still lower than the quality for which farmers are willing to pay (i.e., seeds whose quality level falls between Q^r and Q^n in Figure 3A). Disseminating seed directly to farmers so that they are absorbed in the traditional system of seed supply may be a more effective strategy than trying to supply it through the higher-cost market channels (if it will not be purchased by any seed users). A number of studies suggest giving farmers earlier access to breeding material, encouraging them to visit research stations and make their own selections (Galt 1989; Sperling, Loevinsohn, and Ntambovura 1993). Others propose expanding farmers' role in plant breeding by allowing them to do mass selections on local landraces (Berg et al. 1991; Worede 1992).

5.2. Strategies to Lower Seed Costs

An important way to reduce the cost of seed production and distribution (Figure 3B) is to **promote the production of different seed commodities by seed suppliers likely to have a comparative advantage in producing them.** As discussed in the previous section, seed users are not a homogenous group. Willingness to pay for new seeds will vary with the economic status of seed users. Similarly, the cost of seed supply varies with the type of seed organization. Seed demand from different users can be met by promoting a range of seed organizations with comparative cost advantages in supplying seeds of distinct commodities to different groups. For example, multinational seed companies can meet the seed needs of large-scale commercial farmers whose quality requirements and willingness to pay are higher than smallholder farmers. The seed needs of the latter group can be met more effectively by small-scale firms or community-based seed multiplication and distribution schemes such as farmer seed groups and cooperatives.

Strategies for promoting the local private sector in the seed system include: (1) decentralizing seed multiplication and distribution by providing financial and technical assistance for community-based seed production and sale; and (2) broadening the network of sales agents by making market vendors, stockists, individual farmers, and farmer associations delivery points for public and private seed enterprises.

5.2.1. Decentralization of Seed Production and Marketing

Decentralized farmer-based seed enterprises have several major advantages over more formal centralized operations. Seed production costs are low, seed is available to farmers at the right time, users can purchase the quantity of seed desired, and seed producers are well-informed about the seed and varietal characteristics valued by farmers. However, there are several technical limitations which hinder the performance of the informal seed system. These include:

- **The erosion of seed quality due to poor seed selection and storage facilities.** Although farmers are clearly aware of the relationship between the physical properties of

seed and germination, they are less knowledgeable about the relationship between seed and plant health and of disease transmission through seed (David 1994);

- **Difficulty in maintaining sufficiently clean seeds**, i.e., recognizing and eliminating weed species; and

- **Reliance by farmer-based seed enterprises on retained seed from previous harvests and lack of access to higher-yielding improved varieties from the formal sector.**

NGOs working in collaboration with public and for-profit organizations can improve the technical quality of decentralized seed production and marketing. We found several examples of new farmer-based seed enterprises facilitated by NGOs where farmers were trained in seed multiplication, provided with foundation seed and technical advice, and were responsible for marketing their seed. Ghana has mounted a network of such small-scale seed enterprises for the multiplication and marketing of improved maize seed with assistance from the government, CIMMYT and Sasakawa Global 2000. The network meets about 10% of maize seed needs (Wiggins and Cromwell 1995).

Farmer-based seed enterprises are increasingly involved in producing and distributing improved bean seed in many countries. Since 1994 CIAT's regional program has supported efforts by farmer groups in Uganda to produce bean seed on a commercial basis (Box 3). These enterprises produced more than 3 tons of bean seeds from 1993-96, with all seed sold locally at two to three times the price of grain (David 1997). The success of these farmer-based seed enterprises will depend on building strong local demand for quality seeds to make entrepreneurs' investments in establishing the seed enterprise worthwhile.

Recent technology developments have also made it cheaper and easier for farmer groups to propagate improved tuber crops. Mini-sett technology developed by the International Institute of Tropical Agriculture (IITA) has facilitated the emergence of small seed yam producers in Nigeria. Farmers can grow seed yam from mini-setts (thin slices of yam) in one season and sell the planting material the following season. Improved varieties of cassava can be disseminated in a similar way. Each farmer can be given a few parental stalks of cassava to plant on a portion of the field. In the next season he can harvest enough improved cassava planting material to cover a larger area (Venkatesan 1994).

5.2.2. Improving Infrastructure

Key to reducing seed production and distribution costs is the improvement of transport and information infrastructure to lower the risks and transactions costs of doing business in the seed sector. In addition to renewing road and rail networks, improved extension programs and market

Box 3. Developing Farmer-based Bean Seed Enterprises in Uganda

Initiated in 1993 with the support of CIAT's regional bean program in Eastern Africa, this pilot project was designed to explore alternative systems for the organization, production and distribution of bean seeds in Uganda's Iganga District (David 1994). The promotion of farmer seed enterprises was used as a strategy for: (1) distributing improved varieties; (2) increasing the long-term adoption of improved varieties; (3) involving farmers in the selection of improved varieties; and (4) ensuring a supply of better quality seed of local varieties which could contribute to the preservation of genetic diversity.

A group of 15 farm households has been involved with seed production since 1993. A major problem faced by these seed enterprises is seed marketing. Seed is sold at 3-6 times the price of local grain to recover costs. The seed farmers' association promotes the seed through word of mouth and has explored sales through markets, house-to-house visits and clinics. However, sales have been slow. Seed growers attribute this to the perceived high price of seed and buyer concerns about the marketability of one of the new varieties, which is an unfamiliar seed type. David (1994) lists several lessons from this project, including: (1) avoid grants and require farmers to make some level of financial commitment to ensure maximum commitment to the undertaking; (2) consider the first few seasons as a market trial, multiplying small quantities of seed (e.g., 10-20 kg per variety) and limiting investments in equipment, etc.; (3) avoid high risk production environments at the research stage; and (4) train before seed production begins, especially when indigenous knowledge about seed health is limited.

information systems that include seed can reduce the cost of getting reliable information about new varieties to farmers. The same channels can be used to provide information about farmer demand to seed suppliers.

5.2.3. Revision of Seed Regulations

One of the major challenges ahead will be to revise seed regulations in a way that facilitates the development of a heterogeneous, competitive group of seed producers while protecting the rights of all seed producers and consumers (Tripp 1995a, 1995c; Gisselquist 1996). Agreements that grant monopoly rights for all varieties developed through publicly-funded research to a seed parastatal dampen the incentive for private sector involvement in seed production and marketing. Other regulations that discourage farmer-based seed production include stringent variety release procedures, plant breeder's rights and plant variety protection laws. For example, compulsory certification constrains the multiplication and distribution of some seed types, e.g., open-pollinated maize and sorghum, whose low seed yields and profit margins cannot absorb the costs of stringent and frequent inspections needed to comply with certification standards. Removing

compulsory seed certification and restrictive trade licensing requirements would permit the production of quality seed by smallholders and sale among neighboring farmers. Seed companies could more easily involve smallholders in contract seed production.

Most analysts concur that current seed regulations often use inappropriate standards, do not offer opportunities for farmer and seed producer participation, and are not sufficiently transparent (Tripp et al. 1997). For example, numerous unofficial changes in the statutory instruments affecting the seed system, compulsory seed certification for all crops, and deep budget cuts that have made it difficult for public seed agencies to carry out regulatory functions in a timely way have discouraged the development of seed systems for open-pollinated maize, groundnut and sorghum in Zimbabwe (Rusike, Howard, and Maredia 1998).

There is growing consensus that seed regulatory reform is a fundamental requirement for the establishment and growth of alternative seed organizations. The particulars of the reforms (e.g., whether variety registration and seed certification should be mandatory/voluntary, whether plant varieties should be protected or not) are highly debated in the literature, however. Several general principles of seed regulatory reform emerge from our review:

- **The formulation, management and implementation of regulatory frameworks must be based on the broader participation of state, commercial and local entities in the process;**

- **Seed regulatory reforms must recognize and respond to the heterogeneity of the farming population.** Regulations established for commercial agriculture may be detrimental to subsistence farmers or inadequate for community level seed activities; and

- **Regulatory reforms must provide sufficient flexibility to encourage the expansion and diversification of national seed systems** (Tripp et al. 1997).

5.2.4. Targeted Assistance to Seed-insecure Groups

Carefully targeted public assistance may be the only solution to reach seed users whose willingness to pay for any seed is very low or even zero (Figure 3B), as in the case of chronically seed-insecure farmers or farmers affected by disasters. The provision of free or nominally-priced seed is one strategy to reach these groups of seed users. For many self-pollinated and subsistence crops, the key challenge is providing farmers with seeds of new varieties that they can then maintain themselves. Subsidies can be used to initially disseminate new varieties which can then be distributed through traditional channels. In cases where there is unlikely to be strong and consistent demand for seed in the foreseeable future, the free distribution of small quantities of seed to select farmers may be more cost-effective than attempting to set up a formal and permanent seed infrastructure (Grisley and Shamambo 1993) (Box 4).

5.3. Strategies to Increase the Demand for New Seeds

Strengthening public and private extension programs to increase farmer knowledge about new seed and transmit information about farmer preferences to researchers will help increase the demand for new varieties. Developing other technologies to improve on-farm seed production (such as the yam mini-sett technology described above), and initiatives that improve post-harvest product utilization, expand output markets, and lower production risks are also important. Seed users will pay more for new seed if their expected returns from planting the seed are higher because of lower risks and/or increased revenues (Figure 3C). Thus, measures to strengthen the downstream sectors of the economy are as important as improving the seed system itself.

Farmer demand for seed is also affected by the policy environment. For example, in 1993 the demand for hybrid maize seed in central and northern Nigeria was lower than expected. Farmers said they were influenced by rumors that the government would import large quantities of maize, depressing local maize prices. As a result they curtailed their purchases of hybrid maize seed (Venkatesan 1994).

Box 4. Non-market Intervention in the Bean Seed Market in Zambia

The inefficiency of public seed firms and the reluctance of large-scale private seed firms to enter the market for a self-pollinated crop that is dominated by small scale farmers necessitates alternative solutions to the dissemination problem if small-scale farmers are to benefit from new, higher-yielding varieties. The non-market approach adopted by the agricultural research stations in the Central and Northwestern Provinces in Zambia illustrates a successful approach for disseminating a newly released variety of Carioca bean to smallholder farmers. Under this project, in 1987 four hundred farmers over a wide area were each allocated two kilos of Carioca seed free of charge. The objective of the project was to introduce the cultivar in the hope that farmers would retain and multiply the seed for future use if they found it to have acceptable characteristics. Once the seed had successfully entered farmers' normal seed dissemination channels, there would be no need for subsequent introductions.

A follow-up survey of 64 of the 200 participating farmers in 1989 indicated that 35 of the 55 farmers who produced beans in 1989 were planting Carioca; 36% of the surveyed farmers' total bean land area was cultivated with Carioca; and Carioca was given away 79 times and sold in markets 48 times. These results suggest that the non-market approach for introducing new seed variety may have been successful, and the cost – US$792 – was not prohibitive.

Source: Grisley and Shamambo 1993

6. IMPLICATIONS FOR FARMERS, GOVERNMENT, AND THE PRIVATE SECTOR

Increasing SSA farmer access to improved varieties is critical in the face of evolving biotic stresses and the urgent need to increase food production. Recent advances in breeding and genetic engineering are accelerating the pace of varietal improvement worldwide and offer tremendous opportunities for increasing yields and food security. One challenge will be to increase investments in research and extension organizations to ensure that African farmers and consumers reap the benefits of these innovations. A second major challenge will be delivering the fruits of current and future genetic and seed technological improvements to all groups of seed users in SSA.

Past donor and government efforts to improve African seed systems were based on a narrow view of the transformation process, focusing on the development of the formal sector. These organizations promoted the use of certified seeds and hybrids but were unsuccessful in building demand from the smallholder sector. By contrast, most of the studies we reviewed in this paper stress the complexity of each phase of seed sector development and the dynamic roles of a range of public, private, formal and informal seed organizations in meeting smallholder needs and facilitating the transformation process. There are three key points.

1. **During transformation, the importance of the informal seed sector will decline relatively (but not necessarily absolutely) as the seed system evolves.**

2. **Building horizontal linkages between the informal and formal sectors at each functional level** (e.g., research and development, seed production in Figure 1) **is a critical step** in facilitating transformation.

3. **The public sector has a vital role to play in the transformation process.**

Several conditions are necessary to facilitate the supply of improved seed to smallholders.

- The seed system should supply reasonably good quality seed (but not necessarily certified seed) of both improved and landrace varieties.

- Seeds must be produced at a low cost and sold at a price that competes favorably with grain. This will mean encouraging a plurality of organizations of different scales, sizes and scope to serve multiple types of seed users and crops.

- The seed system should be capable of supplying small quantities of diverse varieties of seed to match local demand. This will entail aiding the development of farmer-based seed enterprises, promoting farmer-to-farmer seed trading, and creating programs that help new and existing farmer-based enterprises gain access to improved germplasm.

In the following sections we turn to a discussion of the roles and alternative policy, program and investment actions that can be taken by farmers, government and the private sector to improve seed system effectiveness.

6.1. Role of Government

The government has a critical role to play in four areas:

1. Providing public goods that are essential to the functioning of both formal and informal sectors, including research targeted to crops and farmers that are of less interest to the private sector;

2. Developing and enforcing regulations for a heterogeneous seed system;

3. Facilitating formal-informal sector linkages at different functional levels, including the promotion of new, more specialized private firms; and

4. Distributing seed or seed vouchers following disasters.

Publicly-funded research and extension activities that test the performance of available seed products (both public and private) in multi-location trials and widely disseminate the results are an important way to help farmers make informed decisions about improved varieties. One way that information can be transmitted to seed users is for formal sector seed packages to carry labels in local languages indicating the name of the variety, number of days to maturity, resistance to disease, yield, cooking time, and other important characteristics. Extension agents can also play an important role in compiling information on seed user preferences and the local/traditional seed channels used by them for public and private sector researchers.

Public research and extension agencies also need to consider how to (1) assist seed-insecure subsistence farmers who may be unable to purchase seed through the market but could benefit significantly from access to varieties with improved drought and disease resistance; and (2) better identify and distribute improved varieties of smallholder crops for which there is little commercial interest. For crops/regions where there is currently no commercial seed market, disseminating seed directly to farmers so that they are absorbed into the traditional system of seed supply may be a more effective strategy than trying to supply it through the higher-cost market channels, if potential users are unlikely to be able to afford them. Free distribution of seeds to introduce new varieties, plants and agricultural inventions was in fact an institutionalized program in the U.S. in the early nineteenth century and continued for almost a century until 1923 (McDonald and Copeland 1997).

Government also has an important role in overseeing the distribution of seeds for disaster relief. Poorly targeted seed relief programs can hamper seed markets by competing with commercial

Box 5. The Impact of Free Input Distribution on Malawi's Commercial Sector

Malawi has an active private sector that is marketing both fertilizer and seeds. However, to alleviate the effects of drought during the 1995-96 agricultural season, the Government of Malawi instituted a Supplementary Inputs Program (SIP) to distribute free fertilizer and seeds to smallholders in selected regions through the Agricultural Development and Marketing Corporation (ADMARC), a parastatal. SIP was designed to reach about 40% of smallholders in the country. An impact assessment by Abt Associates (Chakravarti 1996) indicates that the free distribution of inputs during the 1995-96 season displaced commercial sales, affected prices, and discouraged some entrepreneurs from entering trading activities.

Free fertilizer distributed under SIP represented 14% of total fertilizer use during the 1995-96 season. In contrast, the hybrid maize seed distributed free constituted 51% of total consumption. The combined sales of two commercial companies that produce and distribute hybrid maize seed declined from 5,308 MT in 1994-95 to 3,770 MT in 1995-96, suggesting that free distribution through SIP absorbed some of the potential retail demand. In SIP areas where free fertilizer and maize seeds were distributed, about half of the traders (who were mostly grocery store owners who had diversified into input trading) reported that SIP had a significantly negative impact on prices and sales. Many had unsold seed stocks at the end of the season. On the other hand, a small proportion of traders reported that the SIP seed distribution had a positive impact on their 1995-96 seed sales because of the small quantities distributed and the new interest generated in hybrid seed. Similarly, some traders felt optimistic that the free distribution of fertilizer to first-time users would generate future demand. A large number of traders stated that SIP had deterred them from starting fertilizer and seed marketing activities in 1995-96 season, however.

Source: Newsbriefs 1996

channels, however. For example, in Zambia during 1995-96 three programs operated at cross-purposes in the same areas: Zambia Seed Company tried to sell maize seed for cash through district-level distributors, the Program Against Malnutrition distributed maize seed to be paid in kind at the end of the season, and other NGOs and the Ministry of Agriculture, Food and Fisheries gave maize seed away for free, sending mixed signals to farmers. Similar problems in Malawi are described in Box 5. Where seed markets exist, seed aid should be monetized by distributing seed vouchers rather than providing seed directly to users (Gisselquist 1996; Rohrbach and Mutiro 1996). The government can also facilitate the development of small, private and farmer-based seed enterprises by providing low-interest finance, technical assistance and access to publicly bred parent materials and other varieties.

6.2. Role of Farmers

Farmers need to be better integrated in every aspect of the seed system: as active participants in seed research and release processes, vital links in seed production and distribution through farmer-to-farmer seed exchange networks, independent seed entrepreneurs producing seed for the local market, and as contract seed producers and informed agents/seed traders linked with other private and public seed companies. Case examples from Senegal, The Gambia and Rwanda summarized in Box 6 demonstrate how increased farmer participation can improve seed selection and production methods.

6.3. Role of NGOs and Private Sector Firms

NGOs have traditionally distributed relief seed after emergencies and functioned as a seed supply of last resort for farmers unserved by the public and for-profit private sectors. More recently, NGOs have also begun strengthening the informal seed system, providing a technical liaison with national and international research systems, educating farmers on better seed selection, storage and processing, and providing technical and financial assistance to rural seed enterprises. This support has increased farmer access to improved varieties following the contraction of government-sponsored research and seed supply services. Two cautions are in order. First, because many NGO programs are temporary, providing incentives and funding for permanent research and extension systems to link with smallholder organizations directly would be better than relying on NGOs to provide the connection. Second, a more careful analysis of the economics and sustainability of the smallholder seed firms being promoted by NGOs is needed.

Training new seed producers and reducing the cost of doing business for formal and informal seed sector participants can significantly reduce the costs of seed production and distribution. For example, several NGOs in Zimbabwe and Zambia (CARE, ENDA, COMMUTECH), in partnership with the public extension service, are helping small and large scale seed organizations reduce the transactions costs of dealing with smallholder seed producers, rural shopkeepers and rural clients by (1) providing links to national and international research centers for information and seed of appropriate varieties; (2) training and supervising farmers in seed production, selection, storage and marketing; (3) providing basic training in seed business skills and bookkeeping to rural shopkeepers who are potential agents for formal sector seed suppliers; and (4) providing working capital for input stocks and aggregating orders to be filled by large input supply companies (Rusike, Howard, and Maredia 1998). The government and donor community should support these activities but also ensure that new seed firms do not grow dependent on subsidies. The CARE AGENT program in Zimbabwe, for example, identifies and trains rural traders and initially guarantees credit for input stocks, but “graduates” traders to regular supplier credit as quickly as possible.

A review of NGO experiences in seed activities by Wiggins and Cromwell (1995) suggests that NGOs have played an important role in providing seed aid following disasters and in filling the market gap by supplying seeds of food staples in remote and neglected areas of developing countries. However, in doing so, they have mainly copied the formal sector organizational structure and methods which do not necessarily make economic sense (Tripp 1994). A key issue for NGOs is the sustainability of these efforts given their high cost and heavy reliance on government and donor funding. A number of the studies we reviewed concluded that NGOs can make a greater contribution by supporting the development of small-scale local seed production and distribution enterprises in rural areas, instead of becoming the core of the seed system themselves (Wiggins and Cromwell 1995; Tripp 1994; Gisselquist 1996; Cromwell 1992b).

Box 6. Using Farmer Participation to Improve Seed Selection and Production

1. The On-Farm Seed Project in Senegal and The Gambia

The On-Farm Seed Project (OFSP) in Senegal and The Gambia uses a farmer participatory approach to improve smallholder production of rice seed and food grain. The project began in 1987 as a collaborative effort of USAID, Winrock International, U.S. NGOs, the Peace Corps, and Mississippi State University. The innovation in the OFSP approach is two-fold. First, specific interventions in the local seed systems are based on information gathered in the field. Second, the program focuses on improving farmer systems of seed selection, production, storage and distribution. Through training and demonstrations, OFSP helps farmers learn how to improve the techniques they have been using for centuries. In the process, they learn about new varieties and technologies, share indigenous knowledge and skills, and are challenged and encouraged to review and revise, if necessary, their assumptions about and criteria for selecting, producing, and storing seed (Venkatesan 1994, Osborn 1991).

The focus of the project is rice. New varieties of rice from the research system were given to farmers for on-farm trials (without subsidized fertilizers or other inputs). Extension agents provided advice on seed selection and storage. Since rice is a self-pollinated crop, maintaining varietal purity is not a problem. The project has resulted in the increased availability of good quality, low-cost seed across a wide area. However, a major concern is the sustainability of NGO efforts due to the expense and skilled resource-intensive nature of farmer participatory research.

2. Farmer Participatory Research in Rwanda

The story of women farmers' participation in the bean breeding and selection process adopted by CIAT and ISAR in Rwanda illustrates a successful application of the participatory selection approach. Instead of a formal selection process in which farmers test a set of 2-5 varieties chosen by breeders on their farms, this participatory approach was based on: (1) expert farmers' evaluation of researcher-managed multi-locational trials of about 30 varieties and; (2) farmer selection of varieties for testing on their own fields. Groups of 10-20 expert farmers (identified by their communities) were invited to research stations in their region to evaluate on-station plots at the flowering or pod formation stage and again at maturity. At each stage they were asked to rate the varieties on a scale of one to five. At the end they could select two to three varieties to take home for testing. These selected varieties were tested according to their usual local methods, including manure, soil type, and planting density treatments. The only requirement was to use a local "check" to be placed in an adjacent plot under the same conditions.

The results of this breeder-expert farmer partnership in selecting bean varieties were quite promising: (1) 75% of the varieties selected by farmer experts were grown again the next season; (2) Bush varieties selected by farmers over four seasons of trials performed better than their own local mixtures 64-89% of the time. The farmer-selected varieties also produced substantially more beans, with average production increases as high as 38%. In comparison, breeder-selected varieties outperformed local mixtures in 34-53% of the trials, but production increases were not significant; and (3) The 21 cultivars selected by expert farmers had on average a 71% chance of being grown six seasons later. This compared with a 61% chance for the single most popular variety ISAR had previously released. As a result of the success of the farmer participatory approach, bean breeders released 10 new varieties in three years compared to one variety every two years before the approach was adopted by ISAR.

Source: CGIAR 1994

6.4. Emerging Issues

Developing a seed system based on greater integration, broader participation, and decentralization is an attractive concept but raises several issues (Tripp 1995a). The first concern is the potential risk posed to small-scale seed entrepreneurs if seed stocks go unsold. Mechanisms for assessing the potential demand for seed and protecting the seed seller against the liability for unsold stocks need to be explored.

A second issue involves the regulatory role of the government in an increasingly decentralized seed system. Key questions include: how will farmers be assured of the seed quality? How can seed enterprises and farmers be assured that their contracts will be honored? Strategies emphasizing decentralization must be followed by strong and clear-cut liability procedures to prevent deceptive and fraudulent practices that may otherwise prevail with local and decentralized management of seed activities.

Third, the participatory approach will require an increased investment of farmer time and skills. The degree to which farmers are willing to invest this time is unclear. In addition, the success of a strategy allowing farmers more access to breeding materials will depend to a large extent on the cooperation of public sector plant breeding institutions. Greater farmer access must be balanced by a system in which plant breeders are given due credit for their contributions.

No clear-cut methods for institutionalizing an integrated, decentralized, collaborative and participatory system for continuous seed improvement and distribution have yet been developed. There is an acute need for further research and country-specific case studies on the cost effectiveness of different organizational structures and roles of different actors in the seed system. Country-level case studies are needed to examine (1) the economics of smallholder seed organizations; and (2) the costs and benefits of alternative interventions to strengthen effective demand for improved varieties and improve formal-informal seed sector linkages, including measures to facilitate the establishment of private seed firms.

REFERENCES

Allan, A.Y. 1968. Maize Diamonds: Some Valuable Results from the District Husbandry Trials in 1966. *The Kenya Farmer,* January.

Berg, T., A. Bjoernstad, C. Fowler, and T. Kroeppa. 1991. *Technology Options and the Gene Struggle.* NORAGRIC Occasional Paper Series C: Development and Environment No. 8. Agricultural University of Norway.

Brennan, John P., and Derek Byerlee. 1991. The Rate of Crop Varietal Replacement on Farms: Measures and Empirical Results for Wheat. *Plants, Varieties and Seeds* 4:99-106.

Budden, M. 1986. *Tanseed: Report and Recommendations.* Arusha: Tanzania Seed Company Ltd.

Byerlee, Derek, and Piedad Moya. 1993. *Impacts of International Wheat Breeding Research in the Developing World, 1966-1990.* Mexico: CIMMYT.

CGIAR. 1994. *Partners in Selection: Bean Breeders and Women Bean Experts in Rwanda.* CGIAR Gender Program. Washington, D.C.: CGIAR.

Chakravarti, Ashok. 1996. *Malawi Supplementary Inputs Program: An Assessment of the Impact on Input Markets.* Malawi: APAP III.

CIAT. 1982. *Proceedings of the Conference on Improved Seed for the Small Farmer.* 9-13 August, Cali, Colombia. Cali, Colombia: CIAT.

Crissman, Charles C., Linda M. Crissman, and Carlo Carli. 1993. *Seed Potato Systems in Kenya: A Case Study.* Lima, Peru: International Potato Center.

Cromwell, Elizabeth (ed.). 1990. *Seed Diffusion Mechanisms in Small Farmer Communities: Lessons from Asia, Africa and Latin America.* Agricultural Research and Extension Network Paper No. 21. London: Overseas Development Institute.

Cromwell, Elizabeth. 1992a. *The Impact of Economic Reform on the Performance of the Seed Sector in Eastern and Southern Africa.* OECD Development Centre Technical Paper No. 68. Paris: OECD Development Center.

Cromwell, Elizabeth. 1992b. Supporting Community-Level Seed Production. *Appropriate Technology* 18.4.

Cromwell, Elizabeth. 1996. *Governments, Farmers and Seeds in a Changing Africa.* Wallingford: CAB International.

Cromwell, Elizabeth, Esbern Friis-Hansen, and Mick Turner. 1992. *The Seed Sector in Developing Countries: A Framework for Performance Analysis.* Overseas Development Institute Working Paper 65. London: Overseas Development Institute.

Cromwell, Elizabeth, and B.T. Zambezi. 1993. *The Performance of the Seed Sector in Malawi An Analysis of the Influence of Organizational Structure.* London: Overseas Development Institute.

David, Soniia. 1994. Seed First: Developing Farmer Seed Enterprises in Uganda for the Production and Distribution of Bean Varieties. Paper presented at the Rockefeller Foundation Social Science Fellow Workshop, 14-18 November. Addis Ababa, Ethiopia: ILCA.

David, Soniia. 1997. *Dissemination and Adoption of New Technology: A Review of Experiences in Bean Research in Eastern and Central Africa, 1992-1996.* Network on Bean Research in Africa Occasional Publications Series No. 21. Kampala, Uganda: CIAT.

Douglas, Johnson E. (ed.) 1980. *Successful Seed Programs: A Planning Guide.* Boulder, Colorado: Westview Press.

Dougnac, M., and M. Kokwe. 1988. Traditional Methods Used for Seed Collection, Storage, Supply and their Relationships to Current Developments in Seed Supply Systems. Paper presented at Seminar on Organization of Seed Production and Supply, 30 January - 10 February. Lusaka, Zambia: Svalof/BITS.

FAO. 1994. *FAO Seed Review, 1989-90.* Rome: FAO.

Feder, G. 1982. Adoption of Interrelated Agricultural Innovations: Complementarity and the Impacts of Risk, Scale, and Credit. *American Journal of Agricultural Economics* 64:94-101.

Friis-Hansen, Esbern. 1992. *The Performance of the Seed Sector in Zimbabwe: An Analysis of the Influence of Organizational Structure.* Overseas Development Institute Working Paper 66. London: Overseas Development Institute.

Galt, D.L. 1989. *Joining FSR to Commodity Programme Breeding Efforts Earlier: Increasing Plant Breeding Efficiency in Nepal.* Agricultural Administration (Research and Extension) Network Paper No. 8. London: Overseas Development Institute.

Gerhart, J. 1974. The Diffusion of Hybrid Maize in Western Kenya. Ph.D. dissertation, Princeton University.

Gisselquist, David. 1996. *Toward a Competitive and Modern Seed Industry for Farmers in Southern Africa*. Consultant Report. Washington, D.C.: The World Bank.

Grisley, William. 1993. Seed for Bean Production in Sub-Saharan Africa: Issues, Problems and Possible Solutions. *Agricultural Systems* 43:19-33.

Grisley, William, and M. Shamambo. 1993. An Analysis of the Adoption and Diffusion of Carioca Beans in Zambia Resulting from an Experimental Distribution of Seed. *Experimental Agriculture* 29:379-386.

Heisey, Paul W. (ed.). 1990. *Accelerating the Transfer of Wheat Breeding Gains to Farmers: A Study of the Dynamics of Varietal Replacement in Pakistan.* CIMMYT Research Report No.1. Mexico, D.F.: CIMMYT.

Heisey, Paul W., and John P. Brennan. 1991. An Analytical Model of Farmers' Demand for Replacement Seed. *American Journal of Agricultural Economics* 73.4: 1044-1052.

Henderson, P., and R. Singh. 1990. *NGO-Government Links in Seed Production: Case Studies from Gambia and Ethiopia*. Agricultural Administration (Research and Extension) Network Paper 14. London: Overseas Development Institute.

Herath, H.M.G., J.B. Hardakar, and J.R. Anderson. 1986. Choice of Varieties by Sri Lanka Rice Farmers: Comparing Alternative Decision Models. *American Journal of Agricultural Economics* 64:87-93.

Jaffee, Steven, and Jitendra Srivastava. 1992. *Seed System Development: The Appropriate Roles of the Private and Public Sectors.* World Bank Discussion Papers 167. Washington, D.C.: The World Bank.

Johnson, S. 1989. A Report of the Seed Bulking Activities of the EMI Dryland Farming Project. Embu, Kenya: MEMI Projects. Mimeo.

Kloppenburg, J.R. 1988. *First the Seed: the Political Economy of Plant Biotechnology, 1492-2000.* Cambridge: Cambridge University Press.

Louwaars, N.P. 1994. Integrated Seed Supply: A Flexible Approach. In *Seed Production by Smallholder Farmers: Proceedings of the ILCA/ICARDA Research Planning Workshop held in ILCA, Addis Ababa, Ethiopia, 13-15 June 1994,* ed. J. Hanson. Addis Ababa, Ethiopia: ILCA.

Maredia, M.K., Derek Byerlee, and Peter Pee. 1999. Impacts of Food Crop Improvement Research: Evidence from Sub-Saharan Africa. *Food Policy*. Forthcoming.

McDonald, Miller B., and Lawrence O. Copeland. 1997. Evolution of the Seed Industry. In *Seed Production: Principles and Practices.* New York: Chapman and Hall.

Ministry of Agriculture. 1991. *National Seed Availability Study: Seed Problems, Practices and Requirements Among Small-Scale Farmers in Zambia.* Lusaka: Ministry of Agriculture.

Newsbriefs. 1996. Malawi: How Free Input Distribution Affected Liberalization. *Newsbriefs, Fall 1996.*

Osborn, T. 1991. *Using Farmer Participatory Research to Improve Seed and Food Grain Production in Senegal.* Morrilton, AR: Winrock International Institute for Agricultural Development.

Pardey, Philip, G. J. Roseboom, and J.R. Anderson. 1991. *Agricultural Research Policy: International Perspectives*. Cambridge: Cambridge University Press.

Pioneer Hi-Bred International. 1993. *1993 Annual Report.* Des Moines, Iowa: Pioneer Hi-Bred International.

Pray, Carl, and Bharat Ramaswami. 1991. *A Framework for Seed Policy Analysis in Developing Countries.* Washington D.C.: International Food Policy Research Institute.

Rohrbach, David, and Killian Mutiro. 1996. Formal and Informal Channels for Sorghum and Pearl Millet Seed Supply in Zimbabwe. Paper presented at a national workshop on Seeds Policy in Zimbabwe - Agenda for Action, 30-31 July. Harare, Zimbabwe: ENDA-Zimbabwe and Zimbabwe Biotechnology Advisory Council.

Ruigu, G.M. 1988. The Kenya Seed Industry: Evolution, Current Status and Future Prospects. Paper presented at a seminar on Technology Development and Changing Seed Supply Systems, 22 June. Tilburg, Netherlands: IVO.

Rusike, Joseph. 1995. An Institutional Analysis of the Maize Seed Industry in Southern Africa. Ph.D. dissertation, Michigan State University.

Rusike, Joseph, and Philip A. Donovan. 1995. The Maize Seed Industry in Zimbabwe. *Development Southern Africa* 12.2:189-196.

Rusike, Joseph, and Carl K. Eicher. 1997. Institutional Innovations in the Maize Seed Industry in Eastern and Southern Africa. In *Africa's Emerging Maize Revolution*, eds. Carl K. Eicher and Derek Byerlee. Boulder, Colorado: Lynne Rienner Publishers.

Rusike, Joseph, Julie Howard, and Mywish Maredia. 1998. *Seed Sector Evolution in Zambia and Zimbabwe: Has Farmer Access Improved Following Economic Reforms?* MSU Policy Synthesis No. 31. East Lansing: Michigan State University.

Sperling, Louise. 1993. *Analysis of Bean Seed Channels in the Great Lakes Region: South Kivu, Zaire, Southern Rwanda, and Select Bean-growing Zones of Burundi*. Summary Report. Butare, Rwanda: CIAT Regional Program.

Sperling, Louise, M.E. Loevinsohn, and B. Ntambovura. 1993. Rethinking the Farmer's Role in Plant Breeding: Local Bean Experts and On-Station Selection in Rwanda. *Experimental Agriculture* 29:509-519.

Sperling, Louise, Urs Scheidegger, and Robin Buruchara. 1996. *Designing Seed Systems with Small Farmers: Principles Derived from Bean Research in the Great Lakes Region of Africa.* Agricultural Research and Extension Network Paper No. 60. London: Overseas Development Institute.

Srivastava, Jitendra, and Steven Jaffee. 1993. *Best Practices for Moving Seed Technology: New Approaches to Doing Business.* World Bank Technical Paper No. 213. Washington, D.C.: The World Bank.

Theobald, David M.1992. *Pioneer in Egypt and Ethiopia.* Harvard Business School Report 9-593-003. Harvard University.

Tripp, Robert. 1994. Proximity is Plus: The Economics of Farmer Seed Production and Distribution in Developing Countries. In *Seed Production by Smallholder Farmers: Proceedings of the ILCA/ICARDA Research Planning Workshop held in ILCA, Addis Ababa, Ethiopia, 13-15 June 1994,* ed. J. Hanson. Addis Ababa: ILCA.

Tripp, Robert. 1995a. *Seed Regulatory Frameworks and Resource-Poor Farmers: A Literature Review.* Overseas Development Institute Network Paper 51. London: Overseas Development Institute.

Tripp, Robert. 1995b. Supporting Integrated Seed Systems: Institutions, Organizations and Regulations. Paper presented at the workshop, Integrated Seed Systems for Low-Inout Agriculture, 24-27 October. Malang, Indonesia: MARIF.

Tripp, Robert. 1995c. Seed Regulatory Frameworks and the Availability of Crop Varieties. Paper presented at the World Bank workshop on Easing Barriers to Movement of Plant Varieties for Agricultural Development, June 12-13. Washington, D.C.: World Bank.

Tripp, Robert. 1997. Between States and Markets: Innovations for Small-Scale Seed Provision. Paper presented at the ICRISAT/ICARDA/IITA/GTZ workshop, Enhancing Research Impact Through Improved Seed Supply: Options for Strengthening National and Regional Seed Supply Systems, 10-14 March, Harare, Zimbabwe.

Tripp, Robert, Neil Louwaars, W. Joost van der Burg, D.S. Virk, and J.R. Witcombe. 1997. *Alternatives for Seed Regulatory Reform: An Analysis of Variety Testing, Variety Regulation and Seed Quality Control.* Agricultural Research and Extension Network Paper No. 69. London: Overseas Development Institute.

Venkatesan, V. 1994. *Seed Systems in Sub-Saharan Africa: Issues and Options.* World Bank Discussion Paper 266. Washington, D.C.: World Bank.

Wiggins, Steven, and Elizabeth Cromwell. 1995. NGOs and Seed Provision to Smallholders in Developing Countries. *World Development* 23.3:413-422.

Worede, M. 1992. Ethiopia: A Genebank Working with Farmers. In *Growing Diversity: Genetic Resources and Local Food Security,* eds. D. Cooper, R. Vellve, and H. Hobbelink. London: Intermediate Technology Publications.

Wright, M., T. Donaldson, E. Cromwell, and J. New. 1994. *The Retention and Care of Seeds by Small-scale Farmers.* Natural Resources Institute R2103 (S). Kent, U.K.: Natural Resources Institute.

MSU International Development Papers

How to order from the MSU Bulletin Office:

All domestic orders under $100 must be prepaid either by check or credit card. Make checks payable to MICHIGAN STATE UNIVERSITY. Charges against credit cards (VISA and MasterCard) must be accompanied by the card's full number and expiration date and the cardholder's signature and daytime business/home phone number. Orders totaling $100 or more can be billed by MSU. Institutions and firms should use their official purchase order.

All foreign orders must be prepaid only in U.S. dollars by American Express Money Order, International Money Order, U.S.A. Postal Money Order, U.S. Dollar World Money Order, or check, which must be drawn on a United States bank.

For foreign orders, include an additional 20% for surface postage. For air mail orders, please call for the appropriate amount due.

Please do not send cash. Payment must be included with orders. All sales are final. When ordering from the Bulletin Office by mail, you will need each item's complete identification number and price. Be sure to print your complete address, including ZIP code.

Fill out and send the order form provided to:

MSU Bulletin Office
10-B Agriculture Hall
Michigan State University
East Lansing, MI 48824-1039
Fax: (517)353-7168
Tel: (517)355-0240
E-mail: distbulk@msue.msu.edu

Selected copies are available free of charge to individuals in developing countries, although supplies of these are limited. If free copies are no longer available, MSU will send you order information. USAID officials may obtain free copies through USAID's Center for Development Information and Evaluation (CDIE) or single copies are available free of charge by writing to the above address at Michigan State University.

Available from the MSU Bulletin Office

MSU INTERNATIONAL DEVELOPMENT PAPERS

IDP 13 ..... *Sources and Effects of Instability in the World Rice Market* by T. S. Jayne. 1993. 104 pp. $11.00 **(CDIE reference PN-ABJ-359)**

IDP 14 ..... *The Impact of Agricultural Technology in Sub-Saharan Africa: A Synthesis of Symposium Findings* by James F. Oehmke and Eric C. Crawford. 1993. 33 pp. $7.00 **(CDIE reference PN-ABP-321)**

IDP 14F ..... *L'Impact de la technologie agricole en Afrique subsaharienne: Synthese des conclusions du colloque* par James F. Oehmke and Eric W. Crawford. 1993. 34 pp. $7.00 **(CDIE reference PN-ABQ-056)**

IDP 15 ..... *Market-Oriented Strategies to Improve Household Access to Food: Experience from Sub-Saharan Africa* by T.S. Jayne, D.L. Tschirley, John M. Staatz, James D. Shaffer, Michael T. Weber, Munhamo Chisvo, and Mulinge Mukumbu.* 1994. 61 pp. $9.00 **(CDIE reference PN-ABS-755)**

IDP 16 ..... *Improving the Measurement and Analysis of African Agricultural Productivity: Promoting Complementarities between Micro and Macro Data* by Valerie Kelly, Jane Hopkins, Thomas Reardon, and Eric Crawford. 1995. 44 pp. $7.00 **(CDIE reference PN-ABX-166)**

IDP 17 ..... *Promoting Food Security in Rwanda Through Sustainable Agricultural Productivity: Meeting the Challenges of Population Pressure, Land Degradation, and Poverty* by Daniel C. Clay, Fidele Byiringiro, Jaakko Kangasniemi, Thomas Reardon, Bosco Sibomana, Laurence Uwamariya, and David Tardif-Douglin. 1995. 115 pp. $11.00 **(CDIE reference PN-ABX-501)**

IDP 18 ..... *Promoting Farm Investment for Sustainable Intensification of African Agriculture* by Thomas Reardon, Eric Crawford, and Valerie Kelly. 1995. 37 pp. $7.00 **(CDIE reference PN-ABX-753)**

IDP 19 ..... *Effects of Market Reform on Access to Food by Low-Income Households: Evidence from Four Countries in Eastern and Southern Africa* by T.S. Jayne, L. Rubey, D. Tschirley, M. Mukumbu, M. Chisvo, A. Santos, M. Weber, and P. Diskin. 1995. 83 pp. $9.00. **(CDIE reference PN-ABX-754)**

IDP 20 ..... *Cash Crop and Foodgrain Productivity in Senegal: Historical View, New Survey Evidence, and Policy Implications* by Valerie Kelly, Bocar Diagana, Thomas Reardon, Matar Gaye, and Eric Crawford. 1996. 140 pp. $13.00 **(CDIE reference PN-ABY-173)**

IDP 21 ..... *Fertilizer Impacts on Soils and Crops of Sub-Saharan Africa* by David Weight and Valerie Kelly. 1999. 96 pp $11.00 **(CDIE reference PN-ACG-493)**

IDP 22 ..... *Determinants of Farm Productivity in Africa: A Synthesis of Four Case Studies* by Thomas Reardon, Valerie Kelly, Eric Crawford, Thomas Jayne, Kimseyinga Savadogo, and Daniel Clay. 1996. 50 pp. $7.00 **(CDIE reference PN-ABZ-220)**

WORKING PAPERS

IDWP 39/1 .... *The Impact of Investments in Maize Research and Dissemination in Zambia. Part I: Main Report*. Julie Howard with George Chitalu and Sylvester Kalonge. 1993. 112 pp. $11.00 **(CDIE reference PN-ABS-724)**

IDWP 39/2 .... *The Impact of Investments in maize Research and Dissemination in Zambia. Part II: Annexes.* Julie Howard with George Chitalu and Sylvester Kalonge. 1993. 81 pp. $9.00 **(CDIE reference PN-ABS-727)**

IDWP 40 ..... *An Economic Analysis of Research and Technology Transfer of Millet, Sorghum, and Cowpeas in Niger* by Valentina Mazzucato and Samba Ly. 1994. 104 pp. $11.00. **(CDIE reference PN-ABT-283 or PN-ABS-728)**

IDWP 41 ..... *Agricultural Research Impact Assessment: The Case of Maize Technology Adoption in Southern Mali* by Duncan Boughton and Bruno Henry de Frahan. 1994. 95 pp. $11.00 **(CDIE reference PN-ABS-729)**

IDWP 42 ..... *The Rate of Return to Agricultural Research in Uganda: The Case of Oilseeds and Maize* by Rita Laker-Ojok. 1994. 56 pp. $7.00 **(CDIE reference PN-ABS-730)**

IDWP 43 ..... *Assessing the Impact of Cowpea and Sorghum Research and Extension in Northern Cameroon* by James A. Sterns and Richard H. Bernsten. 1994. 48 pp. $7.00 **(CDIE reference PN-ABS-731)**

IDWP 44 ..... *Food Security II Cooperative Agreement: Project Fact Sheets (1994 Version)* by MSU Food Security II Research Team. 1994. 104 pp. $11.00 **(CDIE reference PN-ABW-277)**

IDWP 45 ..... *The Potential Returns to Oilseeds Research in Uganda: The Case of Groundnuts and Sesame* by Rita Laker-Ojok. 1994. 50 pp. $7.00 **(CDIE reference PN-ACF-662)**

IDWP 46 ..... Understanding Linkages among Food Availability, Access, Consumption, and Nutrition in Africa: Empirical Findings and Issues from the Literature by Patrick Diskin.* 1994. 47 pp. $7.00 **(CDIE reference PN-ABS-732)**

IDWP 47 ..... *Targeting Assistance to the Poor and Food Insecure: A Review of the Literature* by Mattias Lundberg and Patrick Diskin.* 1994. 56 pp. $7.00 **(CDIE reference PN-ABS-733)**

IDWP 48 ..... *Interactions Between Food Market Reform and Regional Trade in Zimbabwe and South Africa: Implications for Food Security* by T.S. Jayne, T. Takavarasha, and Johan van Zyl. 1994. 39 pp. $7.00 **(CDIE reference PN-ACA-239)**

IDWP 49 ..... *A Strategic Approach to Agricultural Research Program Planning in Sub-Saharan Africa*, by Duncan Boughton, Eric Crawford, Julie Howard, James Oehmke, James Shaffer, and John Staatz. 1995. 59 pp. $9.00 **(CDIE reference PN-ABU-948)**

IDWP 49F ..... *Une approche stratégique pour la planification du programme de recherche agricole en Afrique sub-saharienne*, by Duncan Boughton, Eric Crawford, Julie Howard, James Oehmke, James Shaffer et John Staatz. 1997. 67 pp. $9.00 **(CDIE reference PN-ACA-071)**

IDWP 50 ..... *An Analysis of Alternative Maize Marketing Policies in South Africa*, by T.S. Jayne, Milan Hajek and Johan van Zyl. 1995. 51 pp. $7.00 **(CDIE reference PN-ABW-091)**

IDWP 51 ..... *Confronting the Silent Challenge of Hunger: A Conference Synthesis,* by T.S. Jayne, David Tschirley, Lawrence Rubey, Thomas Reardon, John M. Staatz, and Michael Weber. 1995. 37 pp. $7.00 **(CDIE reference PN-ABW-276)**

IDWP 52 ..... *An Ex-Ante Evaluation of Farming Systems Research in Northeastern Mali: Implications for Research and Extension Policy,* by Bruno Henry de Frahan. 1995. 82 pp. $9.00 **(CDIE reference PN-ABW-761)**

IDWP 53 ..... *Who Eats Yellow Maize? Preliminary Results of a Survey of Consumer Maize Preferences in Maputo, Mozambique,* by David L. Tschirley and Ana Paula Santos. 1995. 16 pp. $7.00 **(CDIE reference PN-ABX-988)**

IDWP 54 ..... *Food Security II Cooperative Agreement: Project Fact Sheets (1995/96 Version),* compiled by MSU Food Security II Research Team. 1996. 151 pp. $13.00. **(CDIE reference PN-ABY-072)**

IDWP 55 ..... *Trends in Real Food Prices in Six Sub-Saharan African Countries*, by T.S. Jayne, et al. 1996. 70 pp. $9.00 **(CDIE reference PN-ABY-172)**

IDWP 56 ..... *Food Marketing and Pricing Policy in Eastern and Southern Africa: Lessons for Increasing Agricultural Productivity and Access to Food*, by T.S. Jayne and Stephen Jones. 1996. 40 pp. $7.00 **(CDIE reference PN-ABY-547)**

IDWP 57 ..... *An Economic and Institutional Analysis of Maize Research in Kenya*, by Daniel David Karanja. 1996. 24 pp. $7.00 **(CDIE reference PN-ABY-548)**

IDWP 58 ..... *Fighting an Uphill Battle: Population Pressure and Declining Land Productivity in Rwanda* by Daniel C. Clay. 1996. 28 pp. $7.00 **(CDIE reference PN-ABM-627)**

IDWP 59 ..... *Finding the Balance Between Agricultural and Trade Policy: Rwanda Coffee Policy in Flux* by David Tardif-Douglin, Jean-Léonard Ngirumwami, Jim Shaffer, Anastase Murekezi, and Théobald Kampayana. 1996. 14 pp. $7.00 **(CDIE reference PN-ABY-802)**

IDWP 60 ..... *Agriculture R&D and Economic Growth* by Elias Dinopoulos. 1996. 25 pp. $7.00 **(CDIE reference PN-ABY-804)**

IDWP 61 ..... *Zambia's Stop-And-Go Revolution: The Impact of Policies and Organizations on the Development and Spread of Maize Technology* by Julie A. Howard and Catherine Mungoma. 1996. 39 pp. $7.00 **(CDIE reference PN-ABY-803)**

IDWP 62 ..... *Intrahousehold Allocations: A Review of Theories, Empirical Evidence and Policy Issues* by John Strauss and Kathleen Beegle. 1996. 60 pp. $9.00 **(CDIE reference PN-ABY-848)**

IDWP 63 ..... *Transforming Poultry Production and Marketing in Developing Countries: Lessons Learned with Implications for Sub-Saharan Africa* by Laura L. Farrelly. 1996. 46 pp. $7.00 **(CDIE reference PN-ABY-849)**

IDWP 64 ..... *Market Information Sources Available Through the Internet: Daily to Yearly Market and Outlook Reports, Prices, Commodities and Quotes* by Jean-Charles Le Vallée. 1999. 30 pp. $7.00 **(CDIE reference PN-ACF-672)**

IDWP 65 ..... *Food Security II Cooperative Agreement: Project Fact Sheets (1996 Version)* by MSU Food Security II Research Team. 1997. 190 pp. $15.00 **(CDIE reference PN-ABZ-902)**

IDWP 66 ..... *Improving the Impact of Market Reform on Agricultural Productivity in Africa: How Institutional Design Makes a Difference* by T.S. Jayne, James D. Shaffer, John M. Staatz, and Thomas Reardon. 1997. 39 pp. $7.00 **(CDIE reference PN-ACB-867)**

IDWP 67 ..... *Final Report--Workshop on Experiences and Options for Priority Setting in NARS, August 12-16, 1996, Nairobi, Kenya,* edited by Julie Howard and Eric Crawford. 1997. 76 pp. $9.00 **(CDIE reference PN-ACB-868)**

IDWP 68 ..... *The Effect of Liberalization on Grain Prices and Marketing Margins in Ethiopia,* by T.S. Jayne, Asfaw Negassa, and Robert J. Myers. 1998. 21 pp. $7.00 **(CDIE reference PN-ACC-230)**

IDWP 69 ..... *What Makes Agricultural Intensification Profitable for Mozambican Smallholders?* by Julie A. Howard, José Jaime Jeje, David Tschirley, Paul Strasberg, Eric W. Crawford, and Michael T. Weber. 1998. 98 pp. $11.00. **(CDIE reference PN-ACD-889)**

IDWP 70 ..... *Incentives for Fertilizer Use in Sub-Saharan Africa: A Review of Empirical Evidence on Fertilizer Response and Profitability* by David Yanggen, Valerie Kelly, Thomas Reardon, and Anwar Naseem. 1998. 109 pp. $11.00 **(CDIE reference PN-ACD-890)**

IDWP 71 ..... *Effects of Agricultural Commercialization on Food Crop Input Use and Productivity in Kenya* by Paul J. Strasberg, T.S. Jayne, Takashi Yamano, James Nyoro, Daniel Karanja, and John Strauss. 1999. 28 pp. $7.00 **(CDIE reference PN-ACE-364)**

IDWP 72 ..... *Successes and Challenges of Food Market Reform: Experiences from Kenya, Mozambique, Zambia, and Zimbabwe* by T.S. Jayne, Mulinge Mukumbu, Munhamo Chisvo, David Tschirley, Michael T. Weber, Ballard Zulu, Robert Johansson, Paula Santos, and David Soroko. 1999. 45 pp. $7.00 **(CDIE reference PN-ACE-389)**

IDWP 73 ..... *Macro Trends and Determinants of Fertilizer Use in Sub-Saharan Africa* by Anwar Naseem and Valerie Kelly. 1999. 31 pp. $7.00 **(CDIE reference PN-ACE-290)**

IDWP 74 ..... *Effects of Cash Crop Production on Food Crop Productivity in Zimbabwe: Synergies Or Trade-offs?* by Jones Govereh and T.S. Jayne. 1999. 23 pp. $7.00 **(CDIE reference PN-ACF-371)**

IDWP 75 ..... *Workshop on Agricultural Transformation in Africa: Abidjan, Cote d'Ivoire, September 26-29, 1995* by Moussa Batchily Ba, John M. Staatz, Laura Farrelly, Youssouf Camara, and Georges Dimithè. 1999. 51 pp. $7.00 **(CDIE reference PN-ACF-624)**

IDWP 75F ..... *Atelier Sur la Transformation de l'Agriculture en Afrique*, by Moussa Batchily Ba, John M. Staatz, Laura Farrelly, Youssouf Camara, et Georges Dimithe. 1999. 48 pp. $7.00 **(CDIE reference PN-ACF-390)**

IDWP 76 ..... *Green Revolution Technology Takes Root in Africa* by Julie A. Howard, Valerie Kelly, Julie Stepanek, Eric W. Crawford, Mulat Demeke, and Mywish Maredia. 1999. 66 pp. $9.00 **(CDIE reference PN-ACF-370)**
Statistical Annex and Copies of Questionnaire **(CDIE reference PN-ACF-623)**

IDWP 77 ..... *Increasing Seed System Efficiency in Africa: Concepts, Strategies and Issues* by Mywish Maredia, Julie Howard, and Duncan Boughton, with Anwar Naseem, Mariah Wanzala and Kei Kajisa. 1999 60 pp. $7.00 **(CDIE reference pending)**

..... * Also published by A.I.D./Washington

Mail your marked form
(via mail or fax) to:

MSU Bulletin Office

10-B Agriculture Hall

Michigan State University

East Lansing, MI 48824-1039

Fax: (517) 353-7168

Phone: (517) 355-0240

E-mail:
distbulk@msue.msu.edu

ORDER FORM for Papers Available from MSU

Required with all charge card orders:

Check one: _____ VISA ____MasterCard

Card number: _____

Signature: _____

Expiration Date: _____ Daytime Phone Number: ( )_____

SHIP TO:
Name: _____
Address: _____
_____
_____
_____

Domestic orders totaling $100 or more can be billed by MSU. Institutions and firms should use their official purchase order. All other orders, including foreign orders, must be pre-paid.

Mark each choice with the quantity needed and enter total charges.

____IDP 13 $11.00	____IDWP 45 $7.00	____IDWP 62 $9.00
____IDP 14 $7.00	____IDWP 46 $7.00	____IDWP 63 $7.00
____IDP 14F $7.00	____IDWP 47 $7.00	____IDWP 64 $7.00
____IDP 15 $9.00	____IDWP 48 $7.00	____IDWP 65 $15.00
____IDP 16 $7.00	____IDWP 49 $9.00	____IDWP 66 $7.00
____IDP 17 $11.00	____IDWP 49F $9.00	____IDWP 67 $9.00
____IDP 18 $7.00	____IDWP 50 $7.00	____IDWP 68 $7.00
____IDP 19 $9.00	____IDWP 51 $7.00	____IDWP 69 $11.00
____IDP 20 $13.00	____IDWP 52 $9.00	____IDWP 70 $11.00
____IDP 21 $11.00	____IDWP 53 $7.00	____IDWP 71 $7.00
____IDP 22 $7.00	____IDWP 54 $13.00	____IDWP 72 $7.00
____IDWP 39/1 $11.00	____IDWP 55 $9.00	____IDWP 73 $7.00
____IDWP 39/2 $9.00	____IDWP 56 $7.00	____IDWP 74 $7.00
____IDWP 40 $11.00	____IDWP 57 $7.00	____IDWP 75 $7.00
____IDWP 41 $11.00	____IDWP 58 $7.00	____IDWP 75F $7.00
____IDWP 42 $7.00	____IDWP 59 $7.00	____IDWP 76 $9.00
____IDWP 43 $7.00	____IDWP 60 $7.00	____IDWP 77 $7.00
____IDWP 44 $11.00	____IDWP 61 $7.00	

Sub-Total	$_____
20% (foreign orders, surface mail)	$_____
International Airmail postage (call or e-mail for rates)	$_____
Total Amount	$_____

The MSU International Development Papers published before 1993 (IDP numbers 1-11, IDWP numbers 1-38, and RP numbers 1-31) may be obtained through USAID's Center for Development Information and Evaluation (CDIE) and are not available from the MSU Bulletin Office.

How to Order MSU International Development Papers from USAID:

The MSU International Development Papers published before 1993 (IDP numbers 1-11, IDWP numbers 1-38, and RP numbers 1-31) may be obtained **only** through USAID's Center for Development Information and Evaluation (CDIE).

The CDIE reference numbers are shown on the following list. Document identification necessary to order the full document in paper or microfiche form from the USAID Development Experience Clearinghouse (DEC) is included with the citations.

If you would like to order any of the pre-1993 IDP's, IDWP's or RP's, please do not request them from MSU, but send your request--with the correct CDIE reference number–directly to the DEC:

Mail: USAID Development Experience Clearinghouse

1611 North Kent Street, Suite 200

Arlington, VA 22209-2111 USA

Electronic:

Web site: http://www.dec.org

Email address: docorder@dec.cdie.org

Telephone: +1 703-351-4006

Fax: +1 703-351-4039

If you cannot provide the CDIE reference number for the publication you wish to order, contact the USAID Library, who will supply you with the complete order information:

Telephone: +1 202-712-0579
Fax: +1 202-216-3515

Prices

Documents are provided to USAID employees without charge. Others are required to pay reproduction and mailing/handling costs. Current prices may be obtained by contacting the Document Distribution Unit (docorder@dec.cdie.org) or by searching the Development Experience System (DEXS) available through the DEC's web site (http://www.dec.org). A limited number of microfiche copies are provided without charge to LDC institutions.

Exchange programs

CDIE has established reciprocal agreements with selected development organizations who provide documents or other information resources to CDIE in exchange for distribution of CDIE documents or information. The materials received as a result of these exchange agreements are located in CDIE.

Deposit accounts

Deposit accounts may be established by USAID contractors and other users to facilitate the payment for documents ordered.

Available in A.I.D.'s Development Information System (CDIE)

MSU INTERNATIONAL DEVELOPMENT PAPERS

IDP 1 ..... *Research on Agricultural Development in Sub-Saharan Africa: A Critical Survey* by Carl K. Eicher and Doyle C. Baker. 1982. 346 pp. **(CDIE reference PN-AAL-692)**

IDP 1F ..... *Etude Critique de la Recherche sur la Developpement Agricole en Afrique Subsaharienne* par Carl K. Eicher et Doyle C. Baker. 1982. 345 pp. **(CDIE reference PN-ABA-840)**

IDP 2 ..... *A Simulation Study of Constraints on Traditional Farming Systems in Northern Nigeria* by Eric W. Crawford. 1982. 136 pp. **(CDIE reference PN-AAP-677)**

IDP 3 ..... *Farming Systems Research in Eastern Africa: The Experience of CIMMYT and Some National Agricultural Research Services, 1976-81* by M.P. Collinson. 1982. 67 pp. **(CDIE reference PN-AAM-826)**

IDP 4 ..... *Animal Traction in Eastern Upper Volta: A Technical, Economic and Institutional Analysis* by Vincent Barrett, Gregory Lassiter, David Wilcock, Doyle Baker, and Eric Crawford. 1982. 132 pp. **(CDIE reference PN-AAM-262)**

IDP 5 ..... *Socio-Economic Determinants of Food Consumption and Production in Rural Sierra Leone: Application of an Agricultural Household Model with Several Commodities* by John Strauss. 1983. 91 pp. **(CDIE reference PN-AAM-031)**

IDP 6 ..... *Applications of Decision Theory and the Measurement of Attitudes Towards Risk in Farm Management Research in Industrialized and Third World Settings* by Beverly Fleisher and Lindon J. Robison. 1985. 105 pp. **(CDIE reference PN-AAU-740)**

IDP 7 ..... *Private Decisions and Public Policy: The Price Dilemma in Food Systems in Developing Countries* by Peter Timmer. 1986. 58 pp. **(CDIE reference PN-AAZ-091)**

IDP 8 ..... *Rice Marketing in Senegal River Valley: Research Findings and Policy Reform Options* by Michael L. Morris. 1987. 89 pp. **(CDIE reference PN-AAZ-092)**

IDP 9 ..... *Small Scale Industries in Developing Countries: Empirical Evidence and Policy Implications* by Carl Liedholm and Donald Mead. 1987. 141 pp. **(CDIE reference PN-AAX-734)**

IDP 10 ..... *Maintaining the Momentum in Post-Green Revolution Agriculture: A Micro-Level Perspective from Asia* by Derek Byerlee. 1987. 57 pp. **(CDIE reference PN-AAZ-093)**

IDP 11 ..... *The Economics of Smallholder Maize Production in Zimbabwe: Implications for Food Security* by David D. Rohrbach. 1989. 100 pp. **(CDIE reference PN-ABD-549)**

WORKING PAPERS

IDWP 1 ..... *Farming Systems Research (FSR) in Honduras, 1977-81: A Case Study* by Daniel Galt, Alvaro Diaz, Mario Contreras, Frank Peairs, Joshua Posner, and Franklin Rosales. 1982. 48 pp. **(CDIE reference PN-AAM-827)**

IDWP 2 ..... *Credit Agricole et Credit Informal dans la Region Orientale de Haute-Volta: Analyse Economique, Performance Institutionnelle et Implications en Matiere de Politique de Developpement Agricole* by Edouard K. Tapsoba. 1982. 125 pp. **(CDIE reference PN-AAZ-527)**

IDWP 3 ..... *Employment and Construction: Multicountry Estimates of Costs and Substitutions Elasticities for Small Dwellings* by W.P. Strassmann. 1982. 42 pp. **(CDIE reference PN-AAM-455)**

IDWP 4 ..... *Sub-Contracting in Rural Areas of Thailand* by Donald C. Mead. 1982. 53 pp. **(CDIE reference PN-AAN-192)**

IDWP 5 ..... *Microcomputers and Programmable Calculators for Agricultural Research in Developing Countries* by Michael T. Weber, James Pease, Warren Vincent, Eric W. Crawford, and Thomas Stilwell. 1983. 113 pp. **(CDIE reference PN-AAN-441)**

IDWP 6 ..... *Periodicals for Microcomputers: An Annotated Bibliography* by Thomas Stilwell. 1983. 70 pp. **(CDIE reference PN-AAN-443)**

IDWP 7 ..... *Employment and Housing in Lima, Peru* by Paul Strassmann. 1983. 96 pp. **(CDIE reference PN-AAN-396)**

IDWP 8 ..... *Faire Face a la Crise Alimentaire de l'Afrique* by Carl K. Eicher. 1983. 29 pp. **(CDIE reference PN-AAN-444)**

IDWP 9 ..... *Software Directories for Microcomputers: An Annotated Bibliography* by Thomas C. Stilwell. 1983. 14 pp. **(CDIE reference PN-AAN-442)**

IDWP 10 ..... *Instructional Aids for Teaching How to Use the TI-59 Programmable Calculator* by Ralph E. Hepp. 1983. 133 pp. **(CDIE reference PN-AAP-133)**

IDWP 11 ..... *Programmable Calculator (TI-59) Programs for Marketing and Price Analysis in Third World Countries* by Michael L. Morris and Michael T. Weber. 1983. 105 pp. **(CDIE reference PN-AAP-134)**

IDWP 12 ..... *An Annotated Directory of Statistical and Related Microcomputer Software for Socioeconomic Data Analysis* by Valerie Kelly, Robert D. Stevens, Thomas Stilwell and Michael T. Weber. 1983. 165 pp. **(CDIE reference PN-AAP-135)**

IDWP 13 ..... *Guidelines for Selection of Microcomputer Hardware* by Chris Wolf. 1983. 90 pp. **(CDIE reference PN-AAR-106)**

IDWP 14 ..... *User's Guide to BENCOS A SuperCalc Template for Benefit-Cost Analysis* by Eric W. Crawford, Ting-Ing Ho and A. Allan Schmid. 1984. 35 pp. **(CDIE reference PN-AAQ-682)**

IDWP 15 ..... *An Evaluation of Selected Microcomputer Statistical Programs* by James W. Pease and Raoul Lepage with Valerie Kelly, Rita Laker-Ojok, Brian Thelen, and Paul Wolberg. 1984. 187 pp. **(CDIE reference PN-AAQ-683)**

IDWP 16 ..... *Small Enterprises in Egypt: A study of Two Governorates* by Stephen Davies, James Seale, Donald C. Mead, Mahmoud Badr, Nadia El Sheikh and Abdel Rahman Saidi. 1984. 187 pp. **(CDIE reference PN-AAU-610)**

IDWP 17 ..... *Microcomputer Statistical Packages for Agricultural Research* by Thomas C. Stilwell. 1984. 23 pp. **(CDIE reference PN-AAZ-516)**

IDWP 18 ..... *An Annotated Directory of Citation Database, Educational, System Diagnostics and Other Miscellaneous Microcomputer Software of Potential Use to Agricultural Scientists in Developing Countries* by Thomas C. Stilwell and P. Jordan Smith. 1984. 34 pp. **(CDIE reference PN-AAZ-523)**

IDWP 19 ..... *Irrigation in Southern Africa: An Annotated Bibliography* by Amalia Rinaldi. 1985. 60 pp. **(CDIE reference PN-AAZ-524)**

IDWP 20 ..... *A Microcomputer Based Planning and Budgeting System for Agricultural Research Programs* by Daniel C. Goodman, Jr., Thomas C. Stilwell and P. Jordan Smith. 1985. 75 pp. **(CDIE reference PN-AAZ-525)**

IDWP 21 ..... *Periodicals for Microcomputers: An Annotated Bibliography, Second Edition* by Thomas C. Stilwell. 1985. 89 pp. **(CDIE reference PN-AAZ-526)**

IDWP 22 ..... *Software Directories for Microcomputers: An Annotated Bibliography, Second Edition* by Thomas C. Stilwell. 1985. 21 pp. **(CDIE reference PN-AAZ-528)**

IDWP 23 ..... *A diagnostic Perspective Assessment of the Production and Marketing System for Mangoes in the Eastern Caribbean* by Alan Hrapsky with Michael Weber and Harold Riley. 1985. 106 pp. **(CDIE reference PN-AAZ-529)**

IDWP 24 ..... *Subcontracting Systems and Assistance Programs: Opportunities for Intervention* by Donald C. Mead. 1985. 32 pp. **(CDIE reference PN-AAZ-943)**

IDWP 25 ..... *Small Scale Enterprise Credit Schemes: Administrative Costs and the Role of Inventory Norms* by Carl Liedholm. 1985. 23 pp. **(CDIE reference PN-AAU-615)**

IDWP 26 ..... *Subsector Analysis: Its Nature, Conduct and Potential Contribution to Small Enterprise Development* by James J. Boomgard, Stephen P. Davies, Steve Haggblade and Donald Mead. 1986. 57 pp. **(CDIE reference PN-AAZ-101)**

IDWP 27 ..... *The Effect of Policy and Policy Reforms on Non-Agricultural Enterprises and Employment in Developing Countries: A Review of Past Experiences* by Steve Haggblade, Carl Liedholm, and Donald C. Mead. 1986. 133 pp. **(CDIE reference PN-AAV-001)**

IDWP 28 ..... *Rural Small Scale Enterprises in Zambia: Results of a 1985 Country-Wide Survey* by John T. Milimo and Yacob Fisseha. 1986. 76 pp. **(CDIE reference PN-AAZ-102)**

IDWP 29 ..... *Fundamentals of Price Analysis in Developing Countries' Food Systems: A Training Manual to Accompany the Microcomputer Software Program 'MSTAT'* by Stephen Goetz and Michael T. Weber. 1986. 148 pp. **(CDIE reference PN-AAZ-103)**

IDWP 30 ..... *Rapid Reconnaissance Guidelines for Agricultural Marketing and Food System Research in Developing Countries* by John S. Holtzman. 1986. 75 pp. **(CDIE reference PN-AAZ-104)**

IDWP 31 ..... *Contract Farming and Its Effect on Small Farmers in Less Developed Countries* by Nicholas William Minot. 1986. 86 pp. **(CDIE reference PN-AAZ-105)**

IDWP 32 ..... *Food Security Policy and the Competitiveness of Agriculture in the Sahel: A Summary of the "Beyond Mindelo" Seminar* by Thomas S. Jayne and Nicholas Minot. 1989. 27 pp. **(CDIE reference PN-ABF-570)**

IDWP 33 ..... *Small Scale Manufacturing Growth in Africa: Initial Evidence* by Carl Liedholm and Joan Parket. 1989. 18 pp. **(CDIE reference PN-ABB-945)**

IDWP 34 ..... *Food Security and Economic Growth in the Sahel: A Summary of the September 1989 Cereals Workshop* by Victoire C. D'Agostino and John M. Staatz. 1989. 44 pp. **(CDIE reference PN-ABD-956)**

IDWP 35 ..... *User's Manual for the SADCC Cereals Trade Database Compiled by the University of Zimbabwe and Michigan State University* by David Kingsbury. 1989. 44 pp. **(CDIE reference PN-ABF-378)**

IDWP 36 ..... *Managing Food Security Action Programs in Botswana* by Sisay Asefa. 1989. 36 pp. **(CDIE reference PN-ABF-377)**

IDWP 37 ..... *User's Guide to BENCOS Lotus 1-2-3 Templates for Benefit-Cost Analysis* by Eric Crawford and A. Allan Schmid. 1990. 23 pp. **(CDIE reference PN-ABF-530)**

IDWP 38 ..... *Research Methods in the MSU Food Security in Africa Project: Conceptualizing and Implementing Policy Relevant Studies* by James F. Tefft with Michael T. Weber and John M. Staatz. 1990. 128 pp. **(CDIE reference PN-ABU-249)**

REPRINT PAPERS

RP 1 ..... *The Private Sector Connection to Development* by Carl Liedholm. 1986. 19 pp. **(CDIE reference PN-AAW-353)**

RP 2 ..... *Influencing the Design of Marketing Systems to Promote Development in Third World Countries* by James D. Shaffer with Michael Weber, Harold Riley and John Staatz. 1987. 21 pp. **(CDIE reference PN-AAV-230)**

RP 3 ..... *Famine Prevention in Africa: The Long View* by Carl K. Eicher. 1987. 18 pp. **(CDIE reference PN-AAZ-119)**

RP 4 ..... *Cereals Marketing in the Senegal River Valley* by Michael L. Morris. 1987. 126 pp. **(CDIE reference PN-AAZ-120)**

RP 5 ..... *The Food Security Equation in Southern Africa* by Mandivamba Rukuni and Carl K. Eicher. 1987. 32 pp. **(CDIE reference PN-AAZ-121)**

RP 6 ..... *Economic Analysis of Agronomic Trials for the Formulation of Farmer Recommendations* by Eric Crawford and Mulumba Kamuanga. 1988. 41 pp. **(CDIE reference PN-AAZ-370)**

RP 6F ..... *L'Analyse Economiques des Essais Agronomiques pour la Formulation des Recommandations aux Paysans* par Eric Crawford et Mulumba Kamuanga. 1987. 33 pp. **(CDIE reference PN-AAZ-122)**

RP 7 ..... *Economic Analysis of Livestock Trials* by Eric Crawford. 1987. 36 pp. **(CDIE reference PN-AAZ-371)**

RP 7F ..... *L'Analyse Economique des Essais Zootechniques* par Eric Crawford. 1987. 36 pp. **(CDIE reference PN-AAZ-123)**

RP 8 ..... *A Field Study of Fertilizer Distribution and Use in Senegal, 1984: Summary Report* by Eric Crawford and Valerie Kelly. 1987. 32 pp. **(CDIE reference PN-AAZ-124)**

RP 8F ..... *Enquete sur la Distribution et l'Utilisation de l'Engrais au Sénégal, 1984: Résumé Analytique* par Eric Crawford et Valerie Kelly. 1988. 43 pp. **(CDIE reference PN-ABC-173)**

RP 9 ..... *Improving Food Marketing Systems in Developing Countries: Experiences from Latin America* by Kelly Harrison, Donald Henley, Harold Riley and James Shaffer. 1987. 135 pp. **(CDIE reference PN-AAZ-125)**

RP 10 ..... *Policy Relevant Research on the Food and Agricultural System in Senegal* by Mark Newman, Eric Crawford and Jacques Faye. 1987. 30 pp. **(CDIE reference PN-AAZ-126)**

RP 10F ..... *Orientations et Programmes de Recherche Macro-Economiques sur le Systeme Agro-Alimentaire Sénégalais* par Mark Newman, Eric Crawford et Jacques Faye. 1987. 37 pp. **(CDIE reference PN-AAZ-127)**

RP 11 ..... *A Field Study of Fertilizer Distribution and Use in Senegal, 1984: Final Report* by Eric Crawford, Curtis Jolly, Valerie Kelly, Philippe Lambrecht, Makhona Mbaye, and Matar Gaye. 1987. 106 pp. **(CDIE reference PN-AAZ-128)**

RP 11F ..... *Enquête sur la Distribution et l'Utilisation de l'Engrais au Sénégal, 1984: Rapport Final* par Eric Crawford, Curtis Jolly, Valerie Kelly, Philippe Lambrecht, Makhona Mbaye, et Matar Gaye. 1987. 106 pp. **(CDIE reference PN-ABC-173)**

RP 12 ..... *Private and Public Sectors in Developing Country Grain Markets: Organization Issues and Options in Senegal* by Mark D. Newman, P. Alassane Sow, and Ousseynou NDoye. 1987. 14 pp. **(CDIE reference PN-AAZ-129)**

RP 13 ..... *Agricultural Research and Extension in Francophone West Africa: The Senegal Experience* by R. James Bingen and Jacques Faye. 1987. 23 pp. **(CDIE reference PN-AAV-929)**

RP 13F ..... *La Liaison Recherche-Developpement en Afrique de l'Ouest Francophone: L'Experience du Sénégal* par James Bingen et Jacques Faye. 1987. 32 pp. **(CDIE reference PN-AAZ-130)**

RP 14 ..... *Grain Marketing in Senegal's Peanut Basin: 1984/85 Situation and Issues* by Mark D. Newman. 1987. 16 pp. **(CDIE reference PN-AAZ-131)**

RP 15 ..... *Tradeoffs between Domestic and Imported Cereals in Senegal: A Marketing Systems Perspective* by Mark D. Newman, Ousseynou NDoye, and P. Alassane Sow. 1987. 41 pp. **(CDIE reference PN-AAZ-372)**

RP 15F ..... *Céréales Locales et Céréales Importées au Sénégal: La Politique Alimentaire a Partier Systemes de Commercialisation* par Mark D. Newman, Ousseynou NDoye, et P. Alassane Sow. 1987. 48 pp. **(CDIE reference PN-ABC-326)**

RP 16 ..... *An Orientation to Production Systems Research in Senegal* by R. James Bingen. 1987. 88 pp. **(CDIE reference PN-AAZ-373)**

RP 16F ..... *Orientation de la Recherche sur les Systemes de Productions au Sénégal* par R. James Bingen. 1987. 94 pp. **(CDIE reference PN-AAZ-374)**

RP 17 ..... *A Contribution to Agronomic Knowledge of the Lower Casamance (Bibliographical Synthesis)* by J.L. Posner. 1988. 47 pp. **(CDIE reference PN-AAZ-375)**

RP 17F ..... *Contribution a la Connaissance Agronomique de la Basse Casamance (Synthese Biblographique)* par J.L. Posner. 1988. 47 pp. **(CDIE reference PN-ABC-167)**

RP 18 ..... *Acquisition and Use of Agricultural Inputs in the Context of Senegal's New Agricultural Policy: The Implications of Farmers' Attitudes and Input Purchasing Behavior for the Design of Agricultural Policy and Research Programs* by Valerie Auserehl Kelly. 1988. 30 pp. **(CDIE reference PN-AAZ-376)**

RP 18F ..... *Acquisition et Utilisation d'Intrants Agricoles dans le Context de la Nouvelle Politique Agricole du Sénégal: Implications des Attitudes et du Comportement d'Achat d'Intrants des Exploitants pour l'Elaboration d'une Politique Agricole et de Programmes de Recherches* par Valerie Auserehl Kelly. 1988. 35 pp. **(CDIE reference PN-AAZ-377)**

RP 19 ..... *Farmers' Demand for Fertilizer in the Context of Senegal's New Agricultural Policy: A Study of Factors Influencing Farmers' Fertilizer Purchasing Decisions* by Valerie Auserehl Kelly. 1988. 47 pp. **(CDIE reference PN-AAZ-378)**

RP 19F ..... *Demande d'Engrais de la Part des Exploitants dans les Contexte de la Nouvelle Politique Agricole au Sénégal: Une Etude des Facteurs Influencant les Decisions d'Achat d'Engrais Prises par les Exploitants* par Valerie Auserehl Kelly. 1988. 58 pp. **(CDIE reference PN-AAZ-379)**

RP 20 ..... *Production Systems in the Lower Casamance and Farmer Strategies in Response to Rainfall Deficits* by J.L. Posner, M. Kamuanga, and S. Sall. 1988. 33 pp. **(CDIE reference PN-ABC-162)**

RP 20F ..... *Les Systemes de Production en Basse Casamance et les Stratégies Paysannes Face du Deficit Pluviométrique* par J.L. Posner, M. Kamuanga, et S. Sall. 1988. 33 pp. **(CDIE reference PN-ABC-163)**

RP 21 ..... *Informing Food Security Decisions in Africa: Empirical Analysis and Policy Dialogue* by Michael T. Weber, John M. Staatz, John S. Holtzman, Eric W. Crawford, and Richard H. Bernsten. 1989. 11 pp. **(CDIE reference PN-ABE-627)**

RP 21F ..... *Comment Informer les Decisions Traitant de la Sécurité Alimentaire en Afrique: Analyses Empiriques et Dialogue Politique* par Michael T. Weber, John M. Staatz, John S. Holtzman, Eric W. Crawford, et Richard H. Bernsten. 1989. 13 pp. **(CDIE reference PN-ABD-104)**

RP 22 ..... *The Creation and Establishment of Production Systems Research in a National Agricultural Research Institute: The Senegal Experience* by Jacques Faye, James Bingen, and Etienne Landais. 1988. 25 pp. **(CDIE reference PN-ABC-161)**

RP 23 ..... *Foreign Trade of Agricultural Products and Inputs in Senegal from 1975 to 1984* by Frederic Martin and Alioune Dieng. 1988. 45 pp. **(CDIE reference PN-ABC-164)**

RP 23F ..... *Le Commerce Exterieur de Produits et d'Intrants Agricoles du Sénégal de 1975 a 1984* par Frederic Martin et Alioune Dieng. 1990. 45 pp. **(CDIE reference PN-ABF-529)**

RP 24 ..... *Regulatory Uncertainty and Government Objectives for the Organization and Performance of Cereal Markets: The Case of Senegal* by Mark D. Newman, P. Alassane Sow, and Ousseynou NDoye. 1988. 24 pp. **(CDIE reference PN-ABC-159)**

RP 24F ..... *Incertitude Réglementaire, Objectifs Gouvernementaux, Organisation et Performances des Marchés Céréaliers: Le Cas du Sénégal* par Mark D. Newman, P. Alassane Sow, and Ousseynou NDoye. 1988. 24 pp. **(CDIE reference PN-ABC-160)**

RP 25F ..... *Etude sur la Commercialisation des Céréales dans la Région du Fleuve Sénégal: Méthodologie* par Michael Morris. 1988. 48 pp. **(CDIE reference PN-ABC-172)**

RP 26 ..... *The Regulation and Organization of Cereal Markets in Senegal: Report on the Marketing Campaigns of 1983/84 and 1984/85* by P. Alassane Sow and Mark D. Newman. 1988. 29 pp. **(CDIE reference PN-ABC-165)**

RP 26F ..... *La Réglementation et l'Organisation des Marchés Céréaliers au Sénégal: Situation des Campagnes des Commercialisation 1983/84 et 1984/85* par P. Alassane Sow et Mark D. Newman. 1988. 35 pp. **(CDIE reference PN-ABC-166)**

RP 27 ..... *Farm Level Cereal Situation in Lower Casamance: Results of a Field Study* by C.M. Jolly, M. Kamuanga, S. Sall, and J.L. Posner. 1988. 35 pp. **(CDIE reference PN-ABC-157)**

RP 27F ..... *Situation Céréaliere en Milieu Paysan en Basse Casamance: Résultats d'une Enquête de Terrain* par C.M. Jolly, M. Kamuanga, S. Sall, et J.L. Posner. 1988. 41 pp. **(CDIE reference PN-ABC-158)**

RP 28F ..... *Budgets de Culture au Sénégal* par Frédéric Martin. 1988. 54 pp. **(CDIE reference PN-ABC-168)**

..... *Annexe 1 Budgets de Culture et Analyse des Marges dans le Bassin Arachidier.* 1988. 134 pp. **(CDIE reference PN-ABC-169)**

..... *Annexe 2 Budgets de Culture et Analyse des Marges au Sénégal Oriental et en Casamance.* 1988. 204 pp. **(CDIE reference PN-ABC-170)**

..... *Annexe 3 Budgets de Culture et Analyse des Marges dans la Vallée du Fleuve Sénégal.* 1988. 214 pp. **(CDIE reference PN-ABC-171)**

RP 29 ..... *Agricultural Development and Policy in Senegal: Annotated Bibliography of Recent Studies, 1983-89* by Eric Crawford, R. James Bingen, and Malcolm Versel. 1990. 254 pp. **(CDIE reference PN-ABE-271)**

RP 30 ..... *Lowland Cropping Systems in the Lower Casamance of Senegal: Results of Four Years of Agronomic Research (1982-1985)* by Joshua Posner, Mulumba Kamuanga, and Mamadou Lo. 1990. 130 pp. **(CDIE reference PN-ABU-251)**

RP 31 ..... *Farming Systems Research in Southern Senegal: The Djibelor Experience (1982-1986)* by Mulumba Kamuanga and Joshua L. Posner. 1992. 57 pp. **(CDIE reference PN-ABT-624)**