The Seed Industry for Dryland Crops in Eastern **Kenya**

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KARI

CIMMYT
International Maize and Wheat Improvement Center

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Abstract: The development and promotion of improved crop varieties as well as efficient seed production, distribution, and marketing systems have contributed significantly to increased agricultural production and food security in Kenya. However, these impacts have not been replicated in the semi-arid midlands due to climatic, soil, and institutional factors. Following the liberalization of agriculture in the late 1980s, there has been greater participation of the private sector, non-governmental organizations, and voluntary agencies in the area. This study examined the extent to which these developments affected farmers' access to dryland crops. The study found that the low quantity of seed traded, high cost of production, and high seed supply prices constrained the development of local seed trade. It recommended developing and offering a range of varieties to farmers to increase demand, training to strengthen farmers' capacity to manage seed on-farm, and reduction of high production and distribution costs through further research and institutional improvements. In addition, the "seed loans" model, which has been very effective in the area, should be strengthened.

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Acronyms

AMREF	African Medical Research Foundation
ARIDSAK	Agro-forestry for Integrated Development in Semi-arid Areas of Kenya (sponsored by the Government of Belgium)
CBSBP	Community Based Seed Bulking Project
CIAT	Centro International de Agricultura Tropical
CIMMYT	International Maize and Wheat Improvement Center
Danida	Danish International Development Assistance
DDS	Diocessan Development Services
DFRDP	Dryland Farming Research and Development Project
EASC	East African Seed Company
EEC	European Economic Community
FAO	Food and Agriculture Organization of the United Nations
GoK	Government of Kenya
GTZ	Deutsche Gesellschaft fur Technische Zusammenrbeit (German Agency for Technical Cooperation)
IARC(s)	International Agricultural Research Center(s)
IITA	International Institute of Tropical Agriculture
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
KAP	Kitui Agricultural Program (sponsored by Danida)
KARI	Kenya Agricultural Research Institute
KBS	Kenya Bureau of Standards
KEPHIS	Kenya Plant Health Inspection Service
KFA	Kenya Farmers Association
KSC	Kenya Seed Company
MAP	Makueni Agricultural Development Program (sponsored by Danida)
MIAC	Mid-America International Agricultural Consortium
MIDP	Machakos Integrated Development Program
NDFRC	National Dryland Farming Research Centre
NDFRS	National Dryland Farming Research Station (succeeded by NDFRC)
NGO(s)	Non-governmental organization(s)
NSQCS	National Seed Quality Certification Service
OCDC	Oil Crops Development Corporation
OPV	Open-pollinated variety
UNDP	United Nations Development Program
USDA	US Department of Agriculture
WSGC	Western Seed and Grain Company

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Executive Summary

Even though impressive productivity gains have been achieved in many areas of Kenya with high agricultural potential (in maize, wheat, and horticulture sub-sectors), these impacts have not been replicated in the semi-arid midlands. Climatic, soil, and institutional factors are thought to have constrained the development of seed production, distribution, and trade in dryland crops (other than Katumani Composite B maize seed). Since 1989, the agriculture sector has been largely liberalized, resulting in greater private sector participation in the trade of farm inputs. Voluntary agencies and non-governmental organizations (NGOs) now play an increasingly important role in provision of agricultural extension and other services. This study was carried out during 1997/98 to gauge the extent to which these developments have affected farmers' access to improved varieties of dryland crops and to obtain a better understanding of the seed sector in the region.

Sample surveys on three separate groups—seed users, seed producers, and seed traders— were carried out during 1998 using structured questionnaires. Basic units of observation were smallholder households (both as consumers of seed and those who produce crops as distinct seed enterprises) as well as seed traders. The findings from an informal survey conducted in four semi-arid districts (Kitui, Machakos, Makueni and Mwingi Districts) from December 1997 to February 1998, were used to guide sample surveys, including site selection, sampling, development of questionnaires, and general preparation of the fieldwork.

It was found that public sector agencies such as the Kenya Agricultural Research Institute (KARI), the Kenya Seed Company (KSC), the Kenya Plant Health Inspection Service (KEPHIS), and the Ministry of Agriculture played a key role in varietal development, inspection, certification, and provision of extension advice in the area. There was also an upsurge in the number of non-governmental organizations (NGOs) and voluntary agencies. Several international agricultural research agencies—the International Crops Research Institute for Semi-Arid Tropics (ICRISAT), the International Maize and Wheat Improvement Center (CIMMYT), Centro International de Agricultura Tropical (CIAT), the International Institute of Tropical Agriculture (IITA)—and public universities work in close collaboration with KARI, relevant government departments, and voluntary agencies to develop, produce, and distribute seed. Other public sector agencies involved in the seed sub-sector are the Kenya Forestry Research Institute, the Deutsche Gesellschaft fur Technische Zusammenrbeit (GTZ), Danish International Development Assistance (Danida), and the Belgian government.

The seed users survey showed that farmer's own seed constituted the most important source of seed, followed by government agencies such as KARI, NGOs, and small businesses known as agrovets (small-scale retail businesses set up by local entrepreneurs). The average amount of seed purchased per smallholder was small (about 2-10 kg/household). High prices (1-6 times the price of local seed), unavailability of appropriate varieties, and low quality were mentioned as constraints to the use of improved seed. The most effective mode of providing seed to smallholders was the "seed loan" approach, where farmers are loaned small amounts of seed that they have to repay at the end of the season. These repaid loans are then passed on to other farmers in the area. This method is popular with NGOs and voluntary agencies.

The seed producers survey indicated that smallholder seed farmers produced high quality seed and realized higher prices and gross margins from their seed crop than regular crops. However, low yields and high costs were the main problems.

The seed traders survey showed that the number of traders and the range of varieties sold have increased considerably over the last 10 years. The quality of personnel was high and they could offer advice on seed use. High supply prices, low demand by farmers, and stiff competition were cited as major constraints to expansion of trade.

The data indicated that there was an active market for various types of seed in the area. There was considerable trade in seed of basic grains and horticultural crops, with 71%, 20%, and 6% of farmers reporting having purchased seed of improved varieties of vegetables, maize, and food legumes, respectively. Some farmers also reported purchasing seed of local varieties of maize and food legumes. However, the quantities of seed purchased were low, especially for vegetables and food legumes. Purchases of seed appeared to have been influenced by factors other than price. Low quantities of vegetable and horticultural seed reflected low seed rates associated with vegetable crops and the ceiling on the amount of produce that can be marketed. The amount of grain legume seeds purchased for planting during the short rainy season of 1998 was low. There was some evidence that knowledge about new varieties can spread among farmers relatively quickly, as was the case of Pioneer Hybrid seed.

As the quantity of seed handled through local trade is a small proportion of the seed farmers used, the study recommends matching farmers' requirements with varieties that are developed. Breeders of dryland crops should offer farmers a choice between open-pollinated, self-pollinated, and hybrid varieties. Training should also be provided to build and strengthen farmers' capacities to produce seed on-farm. Further research and improved institutional arrangements should be pursued, to reduce high production and distribution costs.

The "seed loans" model was found to be effective in making seed available to many farmers. It is recommended that this approach be strengthened. Some aspect of transfer of information on farm-level seed management should be tied to the "loan", and feedback on seed performance should be tied to the "repayment".

The objectives of development, production, and provision of seed to smallholders in this region should be set out unambiguously. Given that the farmer's principal source of seed is his/her own farm and that small amounts of seed of improved varieties are brought into the farming systems, the following ordering of the objectives is suggested.

- The first objective should be the introduction of improved varieties into smallholder farming systems in the area.
- Varietal development programs at KARI, IARCs, universities, and (possibly) the private sector should supply basic seed to public/voluntary sector agencies for further bulking.
- Voluntary sector agencies and the private sector should assist with farm level seed shortages.
- The private sector should be encouraged to participate in seed bulking, distribution, and trade and, eventually, varietal development.

The Seed Industry for Dryland Crops in Eastern Kenya

Lutta Muhammad, Kiarie Njoroge, Charles Bett, Wilfred Mwangi, Hugo Verkuil, and Hugo De Groote

Introduction

The development and promotion of improved crop varieties as well as efficient seed production, distribution, and marketing systems has contributed significantly to increased agricultural production and food security in Kenya. Public institutions such as the Kenya Seed Company (KSC), the Kenya Agricultural Research Institute (KARI), and the Ministry of Agriculture have been instrumental in varietal development, seed multiplication, certification, and distribution. Despite this success, the semi-arid regions have lagged behind high potential areas in adoption of improved varieties, crop performance, and seed production (Hassan et al. 1998).

Many factors have been hypothesized as causes for these agro-ecologically-based differences. Most dryland crops are either open-pollinated (e.g., the Katumani maize variety) or self-pollinated (e.g., beans, cowpeas, and pigeon peas), and farmers purchase little new seed every season (Onchere 1976, Muhammad et al. 1985). Controls on trade in farm inputs as well as high production and transportation costs also inhibited the entry of firms into the seed industry. In response to the need for quality seed among smallholder farmers in the region, the Ministry of Agriculture established a seed multiplication and distribution program in 1981 at the National Dryland Farming Research Centre (NDFRC), Katumani. Since then, a number of agencies have assumed various roles in the production and distribution of seeds of dryland crops.

This study was carried out in 1997/98 to identify and characterize the main players in the seed industry in the semi-arid region, to document features of seed production and distribution, and to identify ways in which liberalization of the Kenyan economy influenced the farm inputs sector. The study focused on linkages between all participants in the seed market, promotion by extension services, and research processes that generate new plant varieties at Katumani. The insights gained through this study will contribute to the evolution of institutional research and development policy affecting production and distribution of quality seed for smallholders in the region.

Background

A number of improved dryland crop varieties were developed for smallholders in the region between 1960-90. The Katumani Composite B maize variety, which was released in 1968 and bulked and distributed by the KSC, was widely adopted (Tiffen et al. 1994). Several improved varieties of pigeon peas, cowpeas, beans, *dolichos lablab*, green and yellow grams, cassava and sweet potatoes, sorghum, and millets had been developed by 1981. However, few farmers were able to access seed of these improved varieties because of the absence of a formal bulking and distribution system. To address this shortcoming, partnerships were forged between the Government of Kenya (GoK), and a number of other interested parties such as the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), the Dryland Farming Research and Development Project (DFRDP), the Machakos Integrated Development Program (MIDP), non-governmental organizations (NGOs), and the private sector, to make the seed available to farmers (Egli 1981).

Under such partnerships, a unit responsible for multiplication of basic seed for further bulking was set up at Katumani. Farms with suitable land, managerial, and other resources were contracted for seed multiplication. Since small-scale farmers lacked resources and managerial capability, and costs of inspection and supervision were high, the Sulmac Limited farm in Kibwezi, the Muka Mukuu Cooperative farm in Kangundo, the National Youth Service farm at Yatta, and the Tana and Athi Rivers Development Authority farms at Kibwezi were contracted.

Seed crops were grown under the guidance and supervision of seed specialists and plant breeders at the NDFRS (of which NDFRC is successor) and the University of Nairobi. A minimum of three inspections was performed per season. Harvested seed was shipped to the Hortiseed Company in Nairobi and cleaned, dressed, packed, and labeled. Leaflets containing extension recommendations were included in each packet. Samples were taken to the National Seed Quality Certification Service (NSQCS) for tests on germination rates and purity. The processed seed was then delivered to the Machakos District Co-operative Union for distribution to farmers. Some seeds were distributed directly by the Machakos District Agricultural Office. Seeds of new varieties were provided free to farmers to stimulate interest and awareness. In 1982, one variety of green grams, two varieties of cowpeas from NDFRS, and one variety of pigeon peas from the University of Nairobi were multiplied. Thereafter, varieties that breeders felt were ready for pre-release were included in the program. By 1986, around 100,590 kg of seed of various crops had been multiplied and distributed to over 20,000 farmers (10% of farmers in Machakos District).

The basic institutional structures supporting the Dryland Seed Program were the District Agricultural Office in Machakos and NDFRC, Katumani. Implementation arrangements were mediated through the European Economic Community (EEC)-sponsored MIDP and the GoK/FAO/UNDP sponsored DFRDP. By 1990, EEC support for the Machakos District Co-operative Union and the Dryland Seed Program ended, and private sector participation ceased. Some program activities were continued, however, with different approaches. The last phase of DFRDP involved "lending" farmers small amounts of seed. Farmers bulked this seed, "repaid the loan" in kind and keep the remainder. The repaid seed was "lent on" to other farmers. This method was also popular with NGOs in the area.

The community based seed multiplication and distribution project (Njoroge et al. 1999) succeeded the DFRDP. Under this project, smallholders were identified and were helped to produce seed for their own use and for sale to other farmers in the community (Omanga et al. 1999). Farmers were provided with starter seeds and information to manage seed crops. Seeds produced were packed into 500-gram packets and sent to local seed traders, who sold them to farmers in their area. The projects mentioned above contributed to the establishment of institutional arrangements for multiplication and distribution of quality seed for crops that did not interest the private sector. However, none of the approaches mentioned above survived the respective donor programs.

The Study Area

Rainfall is bimodal in the semi-arid region; with an average seasonal rainfall of 250-400 mm. Inter-seasonal rainfall variation is large with coefficient of variation ranging between 45-58% (Keating et al. 1992). Evapo-transpiration rates are high and exceed rainfall most of the year, except November. Major soils developed on basement rocks (gneisses), quartzite, and plio-pleistocene bay sediments. Predominant soil types include alfisols, acrisols, ferralsols, vertisols, and andasols (Jaetzold and Schmidt 1983).

The region is served by around 8,100 km of roads over approximately 54,000 km^2. More than 83% of these roads are in a poor state of repair. By the time of the study survey in 1997, this proportion had increased substantially because of rain damage. Telecommunications services and electricity are available in major towns only. A variety of tools and implements can be purchased in many outlets and maintained and serviced through networks of local artisans. The Kenya Farmers Association (KFA) stocks and retails farm inputs such as seeds, fertilizers, pesticides, and fungicides through a network of branches and sub-agencies in major town centers. Local traders and cooperative societies in main market centers also trade in farm inputs. There are at least 236 cooperative societies in the region. Loans can be obtained from the Agricultural Finance Corporation, cooperatives, and commercial banks. However, most smallholders do not have access to these credit facilities.

In 1989, the government of Kenya abolished price and other controls on trade in farm inputs (Nyoro 1996). Consequently, neither the Kenya Farmers Association nor any other corporation enjoys a monopoly over farm inputs trade. Agrovets (small-scale retail businesses set up by local entrepreneurs following the liberalization of farm inputs trade) now handle an increasing portion of the trade in farm inputs. In 1995, there were no fewer than 102 small enterprises in the market centers in Machakos District (DAO Machakos 1996).

Methodology

Background information was assembled from secondary sources, key informants, and expert opinions. An informal survey was carried out from December 1997 to February 1998 in four of five Districts—Kitui, Machakos, Mwingi, and Makueni—that fall within the Regional Research Mandate

of the National Dryland Farming Research Centre in Katumani. The survey showed that socioeconomic and agro-ecological profiles and distribution of businesses trading in farm inputs were broadly similar in all four districts. In addition, prevailing cropping systems (which in turn are affected by agro-ecological conditions) influenced seed use and acquisition. The survey yielded indications about available information and gaps. Information needs fell into three categories: users of seed, smallholders involved in seed bulking, and businesses that traded in seed. The survey findings were then used to guide additional structured surveys, site selection, sampling, development of questionnaires, and fieldwork preparation.

Three groups—seed users, seed producers, and seed traders—were surveyed during 1998. The Machakos District was chosen as the site for these surveys for logistical reasons and also because the agro-ecological zones—Lower Highlands (LH), Upper Midland (UM) 2-3; Lower Midland (LM) and Upper Midland 4, 5 and 6 (Jaetzold and Schmidt 1983)—were well represented in the district. Structured questionnaires were designed for each of the three surveys. Basic units of observation were smallholder households as consumers of seed, smallholder households who produce crops as a distinct enterprise, and seed traders.

The seed users survey examined farmers' sources and characteristics of seed they use as well as constraints to increased use of improved seed. Interviews were conducted with heads of households. These included information on personal attributes, resource endowments, and seed acquisition by quantity, type, source and price, as well as problems of seed acquisition. The sampling procedure used was designed to maximize coverage of agro-ecological and socioeconomic variation in the district. A three stage sampling procedure was adopted. Sub-locations were selected from a list of all administrative sub-locations in Machakos Districts. Then, a random sample of 194 smallholdings was drawn from a list of households in villages in each sub-location. The survey was carried out over February-April 1998.

The seed producers survey focused on farmers participating in the community based seed bulking project (CBSBP) to obtain information on the viability of such schemes. A random sample of 50 smallholders was selected from the 500 participating in the CBSBP, in nine administrative divisions in Machakos and Makueni Districts. This sample was reduced to 49 because one farmer could not participate. Information was collected on personal attributes, production costs, yields, and prices. This survey took place during the long rains (LR) season of 1998.

Information on the extent to which formal trade meets farmers' needs for seed, and factors that restrict this trade, were the focus of the seed traders' survey. This survey looked at the number of traders entering or leaving the seed business and reasons for this, retail and wholesale price changes, quantities of seed bought and sold, and how these were affected by seasonality. A questionnaire was designed and administered to a randomly selected sample of 48 seed traders in the area from a list of 102 seed traders provided by the District Agricultural Office in Machakos. The survey was conducted during July and August 1998.

Main Players in the Seed Sub-Sector

To understand forces that propel production, distribution, and use of seed, it is necessary to characterize the seed sub-sector according to organizational (formal or informal), functional (production, processing, transporting, retailing), or institutional criteria (public, private or voluntary sectors). Many different players are active in this sector (Bett et al. 1999). The KSC and KARI are dominant formal institutions that undertake varietal development, seed production, and distribution. The extension service of the Department of Agriculture undertakes dissemination of information about type, availability, handling, and planting procedures. Voluntary organizations supplement these efforts through seed multiplication, distribution, and extension services. The informal sector, made up of smallholders working within the community, handles the bulk of seed used in the semi-arid region. The formal sector handles improved seed varieties whereas the informal sector handles local seed varieties. These roles overlap to varying degrees.

Public sector agencies

The major roles of public sector agencies in the seed industry are seed production, quality control, certification, distribution, and advice on seed use. As mentioned earlier, KARI leads in varietal development and participates in seed production, inspection, and certification. It distributes seed indirectly by providing foundation seed to public, private, and voluntary sector agencies, and through its on-farm research program. The KSC also undertakes varietal development, seed production, and distribution. Large-scale farmers, government, and Agricultural Development Corporation farms in the Rift Valley Province produce KSC seed. Production and processing are carried out in Kitale in western Kenya, while sales to farmers are handled through agents in eastern Kenya. The government also plays an indirect role in seed distribution through ownership of majority shares in KSC.

District Agricultural Offices often undertake production and distribution of seed of dryland crops (other than maize, sorghum, and beans) at farmer training centers and demonstration farms. Provision of seed, as part of the government drought recovery program, is undertaken by the Agriculture Department under supervision of the Provincial Administration Department within the Office of the President.

Quality control and certification activities are carried out by the Kenya Plant Health Inspectorate Services in collaboration with KARI, seed companies, and seed distribution agencies (such as KFA) and seed traders (Ochuodho et al. 1999). National Seed Quality Certification Service (NSQCS) centers in Lanet and Kitale perform most seed quality control activities. The office of the Chief Grader in Mombasa and the Plant Quarantine Station at Muguga carry out seed and plant material inspections at port and border towns, facilitating importation and exportation of seed. To minimize the risk of poor quality seed being sold to farmers, NSQCS carries out post-certification sampling that indicates the quality of seed being distributed just before the planting season. Most dryland crops (maize, sorghum, millet, beans, cowpeas, and pigeon peas) are subject to compulsory certification.

Several international agricultural research centers (IARCs) and public universities are also involved in various stages of seed development, production, and distribution. As a general rule, IARCs and universities work in close collaboration with KARI, relevant government departments, and voluntary sector agencies in the area. ICRISAT (sorghum and pigeon peas), CIMMYT (maize), CIAT (beans), and IITA (cowpeas and cassava) are major IARCs.

Other public sector agencies involved in the seed sub-sector are the District Development Programs (sponsored by the Deutsche Gesellschaft fur Technische Zusammenrbeit (GTZ) in Makueni, Machakos, and Mwingi and the Danida-sponsored Kitui Agricultural Project and Makueni Agricultural Project). The Agro-forestry for Integrated Development in the Semi-Arid Areas of Kenya (ARIDSAK)—sponsored by the Belgian government, KARI, and the Kenya Forestry Research Institute—also make KARI seed available to smallholders in the Kibwezi and Mashuru Divisions in Makueni and Kajiado Districts, respectively. All these agencies work towards making seed available to smallholders either by themselves or through intermediaries such as NGOs and community-based organizations.

Non-governmental organizations and voluntary agencies

There has been rapid growth in NGO participation in seed provision to smallholders (Tripp 1997). In semi-arid areas, NGOs provide seed to smallholders as part of their poverty alleviation strategy. World Vision, Action Aid, and the African Medical Research Foundation (AMREF) are some major international NGOs active in the area.

World Vision identifies needy households and trains them to select maize seed, pigeon peas, cowpeas, beans, and sorghum, with the assistance of research institutes such as KARI and ICRISAT. The African Medical Research Foundation buys seed from KARI and distributes it to women's groups on credit. Women's groups that benefit from AMREF "seed loans" are trained in seed selection techniques. At the time of the survey, Action Aid was negotiating with the University of Nairobi to start seed bulking activities. Diocesan Development Services (DDS) departments of Catholic and Anglican Churches, in the Machakos and Kitui Diocese, have strong rural development programs in the area. The DDS of the Catholic Dioceses of Kitui and Machakos identifies needy groups and provides them with maize, sorghum, and cowpea seed. The DDS community workers then follow-up with these groups to ensure that seed is properly used. The Adventist Relief Agricultural program has been effective in distributing seed to smallholders in Mutomo, Ikanga, and Ikutha in the Kitui Districts.

Private sector

Despite the freeing of farm inputs trade from government controls, the private sector has been reluctant to embrace production of dryland crop seeds. The KSC, the Oil Crops Development Corporation (OCDC), East African Seed Company (EASC) and the Western Seed and Grain Company (WSGC) are among the few firms that participate in the production of dryland crop seeds (Kimenye 1999). However, the amount of seed produced by these companies is small. On average,

the combined annual production for cereals and grain legume seed was about 1,000 tons and 750 tons, respectively (Kimenye 1999), enough for approximately 18,000 ha of grain legumes and 40,000 ha of cereals. Low and erratic demand and difficulties of enforcing contracts with farmers producing seed were cited as reasons for low production. A summary of the main players in the seed sub-sector in the semi-arid region is presented in Table 1.

Table 1. Main players in the seed sub-sector in the semi-arid areas of Kenya.

Main player	Farmer needs assessment	Varietal develop-ment	Provides breeder seed	Provides basic seed	Inspection and certification	Commercial seed production	Provision of seed	Information dissemination	Development support services
Public Sector									
KARI and IARCS	Major	Major	Major	Major	Minor	Minor	Major	With extension services	None
KSC	Major	Major			By KEPHIS	Major	Through sales	Minor	None
KEPHIS	None	None	None	None	Major	None	None	Minor	None
Ministries (agriculture and cooperatives)	Major	None	None	None	None	Minor	Major (relief)	Major	Major
GTZ, KAP, MAP, ARIDSAK	Major	None	None	None	By KARI/KEPHIS	Major	Major	Major	Major
Voluntary Sector:									
Church-based	Major	None	None	None	By KARI/KEPHIS	Major	Major	Major	Major
NGOs (international)	Major	None	None	None	By KARI/KEPHIS	Major	Major	Major	Major
NGOs (local)	Major	None	None	None	By KARI/KEPHIS	Minor	Minor	Major	Minor
Community-based organizations	Major	None	None	None	By KARI/KEPHIS	Major	Major	Major	Minor
Private sector:									
Seed firms (international)	Indirect	Minor	Minor	Minor	By KBS	Minor	Minor	Minor	None
Seed firms (local)	Indirect	Minor	Minor	Minor	By KBS	Minor	Minor	Minor	None
Seed traders	Indirect	None	None	None	None	None	Minor	Minor	None
Local farm produce market	Indirect	None	None	None	None	None	Minor	Minor	None
Local seed farmers	Indirect	Major	None	None	None	Major	Major	Minor	None
Farmers:	Indirect	Minor	None	None	None	None	Recipients	Major	None

Notes: KARI - Kenya Agricultural Research Institute; IARCs – International Agricultural Research Centers; KSC - Kenya Seed Company; KEPHIS - Kenya Plant Health Inspection Service; GTZ - Deutsche Gesellschaft fur Technische Zusammenrbeit (German Agency for Technical Cooperation); KAP - Kitui Agricultural Program (sponsored by Danida); MAP - Makueni Agricultural Development Program (sponsored by Danida); ARIDSAK - Agro-forestry for Integrated Development in Semi-arid Areas of Kenya (sponsored by the Government of Belgium); NGOs – non-governmental organizations; KBS - Kenya Bureau of Standards.

Smallholders' Preferences, Sources, and Seed Management Practices

Just over half (54%) of respondents in the seed users survey were male. Seed sources for these households included own saved seed, local market, seed traders, government (either through the Drought Recovery Program or the Ministry of Agriculture), neighbors, and other farmers. The most important source of seed was farmer's own seed (51%) (Table 2). Seed traders and public sector agencies were also important sources, accounting for about 15% and 10%, respectively.

Table 2. Farmer seed sources, Machakos District, Kenya.

Source	Farmers (%)
Own	51
Traders	15
Public sector agencies	10
Local market	7
Neighbor	3
Other	14

Table 3. Criteria used in selection of maize seed, Machakos District, Kenya.

Selection criteria	Farmers (%)
Cob size	31
Earliness	7
Number of nodes	5
Disease and pest free	4
Grain cover	3
Earliness and grain cover	3
Other	11
No selection criteria	36

A majority of respondents stated that they did not grow seed crops separately from regular farm produce. Selection of plants for seed took place in the field. Characteristics farmers used to select seed were cob and grain size, earliness, grain cover, resistance to pests and diseases, correct distance between nodes, combination of maturity, and grain cover. Cob size (31%), earliness (7%) and number of nodes (5%) were common selection criteria. A significant proportion (36%) of respondents did not reveal their selection criteria (Table 3).

Few farmers had training in seed management. Just over 18% had some training in agriculture and, out of these, 12% had some training in some aspects of seed management, including seed selection (5%).

Smallholder Seed Production

To ensure a more effective mechanism for production of dryland crops, the NDFRC, in collaboration with partners, has been experimenting with options to involve smallholders in schemes to produce seed for their own use and for sale. A survey of 49 smallholders who participated in the community based dryland seed bulking project (CBSBP) was carried out to facilitate understanding of the economics of smallholder seed production and other issues that may be significant.

Community based seed bulking program

The CBSBP was launched in 1997 to address farmers' needs for quality dryland crop seeds. Improved varieties of grain legumes and cereals, officially released by the Ministry of Agriculture, were included in this program (Table 4). Farmers were advised to implement recommended practices to maximize yields. Recommendations for land preparation, planting time, plant densities and spacing, timely weeding, protection against diseases and insect pests, fertilizer and manure application, harvesting and post-harvest treatment operations were developed for each crop (Omanga 1998, Njoroge et al. 1999).

Table 4. Improved varieties in community based seed bulking program, Machakos and Makueni Districts, Kenya.

Crop	Improved Varieties
Cowpea	K80; M66; KAT 27-1
Beans	KAT B1; KAT B9; KAT x56
Pigeon pea	KAT 60/8; ICPL 87091(KAT Mbazi 1); KAT 777
Green grams	KAT Ndengu 26
Dolichos lablab	DL2
Maize	Katumani Composite B (KCB); Dryland Composite C (DLC)
Sorghum	Seredo; KARI Mtama 1
Millets	ICVM 221

Source: NDFRC (1998).

During the long rainy season of 1997 (March-April), 20 farmers participating in the program received 20-30 kg of breeders' seeds per crop variety, which were grown under the supervision of plant breeders from KARI. A total of 8,172 kg of seed were produced, cleaned, treated with chemicals, packed in 4-kg transparent polythene bags, and distributed to farmers. The Makueni Agricultural Project and World Vision distributed the seeds to divisions in Makueni Districts**.** During the crop-growing period, extension staff followed up with visits to ensure that proper practices were followed. Both research and extension staff inspected the crop at flowering and maturity stages. The expected target of producing 18,000 kg was not realized due to drought and insect pest damage. Only 180 mm of rainfall fell, and there was a serious outbreak of aphids that "blackened" the leaves and pods of grain legume crops. At least 54,325 kg of seed was produced during the short rainy season of 1997/8.

In the long rainy season of 1998, 500 farmers were organized into groups of 30-50 farmers. Each group contracted or rented a store for use by members, organized seed production, planned and implemented related activities, purchased inputs, and marketed seed that they produced. The need to strengthen training of these farmers in seed production techniques was recognized. Transfer of skills through visits, demonstrations, field days, and workshops was carried out.

Characteristics of seed producers

The criteria for membership to the CBSBP were ownership of an ox-plow, capability to acquire necessary inputs, and ability to read and understand labels and leaflets. Another requirement was that the farmer was able to set aside at least 0.4 ha for seed production and to exercise isolation as stipulated. Table 5 presents the characteristics of seed producers who participated in the CBSBP.

A wide range of age and income sub-categories was represented in the sample. Although income from non-farm sources in 1997 was comparatively high, the majority (55%) of respondents were primarily farmers. A significant proportion were part-time farmers who worked in business (15%), services (13%), and crafts (8%).

Seed production costs

Seed producers in the CBSBP were advised to follow recommended practices for obtaining good yields and prices. The survey indicated that the standard of crop management was relatively high. For example, inorganic fertilizers and pesticides were used. Field inspections were staggered over the growing period across farms. These "in the field" inspections were carried out at grain filling, podding, and silking stages. Roguing was performed as recommended.

Five crops were chosen for inclusion in the analyses: maize, pearl millet, beans, cowpeas, and sorghum. Pre-harvest production costs are presented in Table 6. Typically, seed accounts for a relatively small proportion of production cost. However, for crops with high seed rates like common beans, seed can be a significant proportion of total production costs. Accordingly, seed cost was included in the analysis although seed was either obtained from the farmer's own farm or other sources without direct payment. Fertilizers (for maize) and labor (for beans, pearl millet and cowpeas) represented the highest costs. Seed costs for beans also represented a large proportion of pre-harvest production costs. The fixed inspection fee of KSh 1,000/ha translated into 3-10% gross-margin of the farmer's seed enterprise.

Table 5. Characteristics of smallholdings participating in the community based dryland seed bulking project, CBSBP, Machakos and Makueni Districts, Kenya.

	Mean value		Minimum value		Maximum value	
Variable	Male (N=32)	Female(N=17)	Male	Female	Male	Female
Age (yr)	54	47	36	25	87	69
Farming (yr)	26	25				
Non-farm income (KSh†)	69,093	19,466	5,000	10,000	240,000	36,000
Farm size (ha)	4.2	5.2	0.5	0.5	16.4	19.7
Crop area (ha)	1.9	1.7	0.3	0.3	6.2	4.1

Note: †US$ 1 = 63KSh (1997)

Table 7 presents post-harvest costs of producing seed crops. Apart from inspection fees and water for spraying pesticides, all other costs varied by crop. Packaging and shelling costs were high, while treatment and sorting costs were modest. At KSh 4/km, transport was the largest single cost item. It is probable that this reflected the state of roads damaged by *El Niño* rains.

Performance of seed crops in smallholder farming systems

Typically, maize seed production in Kenya is four times more profitable than commercial maize production (Nyoro 1996). One motivation for this study was to assess the extent to which such performance measures can be replicated for smallholder seed producers in the semi-arid region. Performance of seed enterprises within smallholder farming systems could be a useful indicator of financial viability of the schemes such as CBSBP. The performance of seed enterprises was assessed using data obtained from the seed producers' survey. Indicators were yield, price, and gross-margins. Smallholders' non-seed crops formed the benchmark for this assessment. The results are presented in Table 8.

Table 6. Pre-harvest production costs for seed crops†(excluding cost for land), Machakos and Makueni Districts, Kenya.

	Cost Item							
Crop	Pesticide (kg / ha)	Fertilizer (kg / ha)	Pesticide (KSh‡ / ha)	Fertilizer (KSh‡ / ha)	Seed (KSh‡ / ha)	Labor (KSh‡ / ha)	Pre-Harvest (KSh‡ / ha)	Pre-harvest (KSh‡ / kg)
Maize	2.4	158	2,070	3,941	823	1,154	7,989	5.28
Pearl Millet	0.9		787		242	2,395	3,424	3.50
Beans	1.7	71	1,444	1,768	2,179	3,929	9,319	10.52
Cowpeas	1.5	17	1,271	416	775	3,929	6,391	4.50
Sorghum	2.0		1,721		102	23,954	4,217	4.33

Note: †Computed from survey data.
‡ US$ 1 = KSh 63 (1997)

Table 7. Post harvest, irrigation, and inspection costs† for seed crops (KSh / ha), Machakos and Makueni Districts Kenya.

Crop	Packaging	Shelling	Treat ment	Sorting	Water for spraying pesticides	Inspec-tion	Trans-port	Total post-harvest cost (KSh‡ / ha)	Total post-harvest cost (KSh‡ / kg)
Maize	4,349	2,899	289	1,007	600	1,000	5,799	16,892	11.17
Pearl Millet	2,790	1,860	186	646	600	1,000	3,720	11,732	12.00
Beans	1,599	1,066	106	370	600	1,000	2,132	7,406	8.36
Cowpeas	4,257	2,838	283	986	600	1,000	5,676	17,059	12.02
Sorghum	2,925	1,950	195	677	600	1,000	3,900	12,222	12.54

Note: †Cost figures computed from information obtained from CBSBP.
‡ US$ 1 = KSh 63 (1997).

Table 8. Yields, prices, and gross margin of smallholder seed crops, Machakos and Makueni Districts, Kenya.

	Yield (kg / ha)		Price (KSh† / kg)		Gross margin (KSh† / ha)	
Crop	Seed	Non-seed	Seed	Non-seed	Seed	Non-seed
Maize	1,512	1,449	32.9	8.2	22,356	10,393
Pearl millet	978	930	48.5	NA	29,951	NA
Beans	886	533	48.4	21.6	13,029	9,115
Cowpeas	1,419	614	31.2	19.3	20,843	7,115
Sorghum	975	900	17.0	12.0	-4,739	13,029

Note: †US$1 = KSh 63 (1997)

Average yields of cowpea seed crops fell slightly short of the expected yield under similar management and weather conditions. Yields of all other seed crops were below expectation by large margins. Comparing seed and non-seed crops, there were no striking differences in yields of maize, pearl millet, and sorghum. There were, however, large differences between yields of seed and non-seed crops for beans and cowpeas. The fertilizers applied in the case of beans, and effective pest control in the case of cowpeas, may account for this difference. The prices for seed and non-seed crops shown in Table 8 were actually paid to farmers. Seed prices were consistently higher than non-seed prices. The gross margin for sorghum was negative because of high costs and low prices. Gross margins for seed maize and cowpeas were substantially higher than corresponding non-seed crops. Most of this difference can be attributed to high seed prices (2 and 4 times for cowpeas and maize, respectively). Low yields and high costs appear to have eroded the difference between bean seed and the corresponding non-seed crop.

Maize seed sold for four times the price of maize grain (Table 8). Yields for seed and non-seed maize were roughly the same but seed production costs were higher for seed maize - 16.5 KSh/kg (or 24,881 KSh/ha, land costs not included). The gross margin of maize seed production is twice that of non-seed maize. Gross margins were also high for pearl millet and cowpea seed but less for beans and negative for sorghum, which received a very low price that season.

Analysis

Yields of seed crops were generally higher than non-seed crops, indicating higher standards of management. Although prices for seed crops were substantially below corresponding commercial seed prices, they were considerably higher than non-seed crop prices. This suggests that market opportunities for this type of seed exist. Based on gross margins as indicators of profitability, it was shown that four out of five seed crops were more profitable than the corresponding non-seed crops. Both pre- and post-harvest costs were high. Expenditure on fertilizer dominated pre-harvest costs, while packaging, threshing, and transportation expenses dominated post-harvest costs. It should be noted that the use of high-cost inputs, such as fertilizers and pest control agents, in crop production is not common among farmers, given the high risk that characterizes farming in the region. Thus, the continuation of these practices may not be guaranteed beyond the termination of donor support for the project.

As mentioned earlier, large-scale farms were contracted to produce seeds of dryland crops in the past. The per-unit transport and storage costs for smallholders participating in the CBSBP represented just under 11% (for large-scale farms, the proportion was 8%) of total cost. The share of seed growers' costs as a proportion of total cost was lower (67%) for the seed production scheme (based on large-scale farm characteristics described earlier), than for CBSBP farmers (78%). Seed processing costs, however, were lower for CBSBP farmers than large-scale farmers (Muhammad et al. 1999). Seed produced for the CBSBP was transported to Katumani for processing while seed produced by large-scale farmers was sent to the Hortiseed Company in Nairobi for processing. Evidence from Zimbabwe suggests that while smallholders generally obtain low yields and need close supervision if contracted as seed producers, they are more inclined to accept lower prices for seed that has not been processed than large-scale farmers (Tripp 2000). If smallholder seed growers are clustered in close proximity to each other, as was the case with CBSBP, the unit cost of supervision and seed assembly can be reduced. A potential problem associated with seed production by smallholders is the temptation to sell seed for immediate payment (Kimenye 1999, Tripp 2000).

Seed Distribution and Trade

As Gisselquist and Grether (2000) observed, deregulation of farm inputs trade can lead to significant increases in the range and quality of inputs available to farmers. As noted earlier, the Government of Kenya started to implement reforms in many sectors of the economy over the period 1989-1996. This shift in public policy yielded a number of significant results for the farm inputs sector in general and the seed sub-sector in particular. Multinational companies, such as Pioneer and Cargil, and local firms, such as the Oil Crop Development Company (OCDC), the East African Seed Company (EASC), and the Western Seed and Grain Company (WSGC), entered the seed market as producers and traders (Ndambuki 1998, Ng'ang'a 1998, Kimenye 1998, Kimenye 1999). According to Ochuodho et al. (1999), there are 31 registered seed companies in the country. Kenya Seed Company multiplies and distributes maize and small amounts of sorghum and beans. Kimenye (1999) reported that the EASC, OCDC, and WSGC produced relatively small amounts of seed and sold little to smallholders; local and foreign NGOs were their main customers. All reported low and erratic demand in the smallholder sub-sector. At the local level, numerous agrovet businesses, established by small-scale entrepreneurs, are now major suppliers of commercial seed and fertilizers.

While some farmers in the region buy maize seed from a variety of sources, attempts to incorporate seed of improved varieties of other dryland crops into this distribution and trade network on a commercial basis have met with little success. Several factors have been hypothesized as constraints to private sector involvement in seed trade in the region. These include high costs of production, low and unreliable yields, and high transaction costs. Weak and unreliable demand is also believed to constitute a major constraint to the development of private trade in dryland crops. This lack of demand is attributable to farmers' preferences for recycled seed, lack of funds to purchase seed, lack of information about performance of varieties, distant

and unreliable seed sources, and high prices. Non-availability of seed, when required by farmers, also undermines demand for improved seed varieties. Because private sector involvement in commercial seed trade is weak, the task of introduction of improved varieties and distribution of quality seed has been left to public and voluntary sectors. This may not be appropriate for two reasons. First, distortions in price determination and resource allocation are likely to be introduced. Secondly, current seed distribution activities in the region rely on external support and this is not sustainable.

Characteristics of seed traders

In 1996, it was estimated that there were at least 102 small businesses engaged in the seed trade in market centers throughout Machakos District (DAO Machakos 1996). This number did not include many small rural retailers who also stock small amounts of seed. The main seed outlets, however, were the KFA, Timsales Limited, Maathai Enterprises, and Ngelani Agrovet, which are all based in Machakos Town. At the time of the survey, KFA and Timsales had scaled down trading activities considerably. Information in this section pertains to the sample of 48 businesses in Machakos District engaged in the farm inputs trade.

Most seed traders are male (77% men), relatively young (mean age 37), fairly well educated (average 13 years in formal education), and enjoy additional income from non-trading sources (an average of KSh 116,000/year). More than three-fourths (89%) had non-trading income during 1997. The most frequent income sources were farming (52%), clinical services (17%), and consultancy (10%). The non-trading occupations of seed traders were also telling—just under half were farmers (48%), while veterinarians and consultants comprised 26% and 14%, respectively.

Seed trading businesses were relatively young (mean number of trading years was 5.5). Most (92%) were established over the last eight years, i.e., following the liberalization of farm inputs trade, with almost a quarter established during 1996. Seed was by no means the only item of trade. Other items were pesticides (89%), fertilizers (87%), animal feed (81%), pharmaceuticals (40%), animal drugs (20%), farm produce (15%), and household goods (15%).

Demand and supply of seed

Table 9 shows the proportion of farmers who purchased seed for planting during the short rainy season of 1997/98. Most farmers (71%) reported that they purchased vegetable crop seeds despite high prices, followed by farmers who bought improved maize seed (20%). Some farmers bought improved bean (5%) and cowpea seeds (0.8%). Some farmers reported that they bought local varieties of maize, beans, and cowpeas (1.2, 0.8, and 0.8%, respectively).

Table 9. Types of seed bought by farmers, Machakos District, Kenya, short rains 1997/98.

Crop	Variety	Farmers (%)
Vegetables	Improved	71.0
Maize	Improved (mostly KCB†)	16.7
Maize	Pioneer	3.3
Maize	Local	1.2
Beans	Improved	5.3
Beans	Local	0.8
Cowpeas	Improved	0.8
Cowpeas	Local	0.8

†KCB – Katumani Composite B

This suggests that there is an active market for local and improved varieties of maize and beans. Although the Pioneer Hybrid maize variety was new in the area, 3% of farmers purchased this seed.

The amount of seed purchased by smallholders, and prices they paid during the short rainy season of 1997/98, are presented in Table 10. The average amounts of seed purchased per smallholder were relatively low. The largest amounts were for local maize (33 kg) followed by improved maize (12 kg). The average amount of Pioneer Hybrid maize seed purchased was 1.7 kg. The price of improved seed of some other crops, such as pigeon peas, was also only slightly higher than local seed of the same crops. This may indicate either that performance was not significantly better or that farmers were not willing to pay more for these improved varieties.

Seed traders reported that transport, handling, and storage costs for seed averaged KSh 374.9/trader. These costs represented some 12% of the value of improved seed sold. As all traders in the sample stocked seed, this finding was not surprising. Seed quantities stocked were small and transportation costs were shared among many commodities in the business portfolio. Transport, handling, and storage represented 71%, 21%, and 8% of trading costs, respectively (Table 11). The fact that farmers bought only small amounts of seed, constituted a more serious constraint to the development of seed trade than trading costs.

Most seed traders do not repack seed (97%) because it would undermine customer confidence. Local farmers (87%), other traders (9%), schools, and NGOs (4%) were the main customers. Most traders (53%) adjusted prices according to competitors' prices. The remainder used recommended retail prices (20%) and markups on supply prices (27%). A majority (92%) knew seed and varieties that were suitable for respective localities and passed on this advice to buyers.

Seed sales were high during the onset of the rains (March/April) (Table 12), except for horticultural seed, for which there was demand throughout the year where irrigation was available. The lowest sales were during the middle of the season, in May/June and July/August.

Table 10. Quantity and price of seed purchases, Machakos District, Kenya.

	Price (KSh† / kg)		Improved / local price ratio	Average quantity (kg / client)	
Crop	Local	Improved		Local	Improved
Beans	54.7	64.4	1.2	6.2	10.2
Cowpeas	43.4	53.0	1.2	4.0	4.5
Green grams	35.0	52.5	1.5	2.1	4.3
Pigeon Peas	41.7	46.4	1.1	5.5	3.9
Sorghum	2.4	16.2	6.8	2.4	3.1
Vegetables	-	318.7	-	-	2.6
Maize (non-Pioneer)	21.0	72.6	3.5	33.0	11.9
Maize (Pioneer)	-	85.0	-	-	1.7

Note: †US$ 1 = KSh 63 (1997)

Table 11. Seed traders' costs, Machakos District, Kenya.

Cost item	Average cost (KSh / trader)	%
Handling	77.8	21
Transport	266.3	71
Storage	30.8	8
Total	**374.9**	**100**

Source: Muhammed et al. 1999.

Table 12. Frequency of seed sales by seed traders, Machakos District, Kenya, 1997.

	Frequency (no.)					
Amount	Jan / Feb	Mar / Apr	May / Jun	Jul / Aug	Sep / Oct	Nov / Dec
Lowest	12	0	29	31	0	10
Average	1	0	7	0	1	3
Highest	0	12	0	0	4	5

Constraints and opportunities

Two thirds of respondents reported selling as much seed as they expected at the beginning of the season. However, 47% stated that they did not intend to increase stock. Although capital for establishing, expanding, or facilitating business operations can have important implications for an enterprise, this did not appear to be the case for seed traders in the area. While 95% of respondents stated that they knew about credit sources, only 30% used them. Credit represented an opportunity for expanding seed trade.

Some farmers complained of poor seed quality, claiming that local seed yielded more than improved varieties like Katumani Composite B. For purchased certified seed, about 15% of farmers said they had received adulterated seed at least once before. This suggests that the mechanism used by NSQCS inspectors to enforce standards at the point of sale can be circumvented by unscrupulous agents. As Gisselquist and Grether (2000) implied, the NSQCS strategy to tackle this problem should build on farmers' existing knowledge of inputs. Farmers cited high prices charged by traders as a major hindrance to increased use of purchased seed. Seed traders cited high seed prices charged by suppliers as a factor that limited participation and expansion of seed trade. However, the main constraint to the expansion of trade was the low quantity of seed farmers purchased.

The main problems traders faced were competition (35%), low sales (23%), seeds that do not sell fast enough (15%), high transportation costs, and inappropriate packaging (7.7%). High supply prices and competition were the greatest constraints. While traders viewed competition as a constraint, society could view it as an opportunity. Beneficial impacts are expected to flow to farmers from the use of improved seeds through increased efficiency, lower costs of acquiring and providing seed, and lower prices paid by farmers. Overall, the number of urban- and rural-based retail outlets increased over the period from 1987-97, bringing seed closer to farmers. The number of varieties has increased over the same time period and farmers now have a wider range of germplasm to choose from. The impacts of change in public sector employment policy, which terminated automatic recruitment of graduates of higher learning institutions into the civil service, are evident in the high quality of owners, managers, and operators of the farm inputs businesses.

Nearly all seed traders in the sample spread transport and storage costs over many commodities, to the extent that they did not consider that such costs constrained the development of seed trade in the area.

Trends in the seed trade

According to most seed traders, the number of suppliers has increased over the last 10 years (81% of the respondents) but the seed availability of these suppliers has actually decreased (64%) (Table 13). Other major changes observed by most traders are the increased number of seed customers (74%) and an increase in price (91%). Most traders think there has been no change in the profit margin

Table 13. Subjective assessment of changes in seed trade over 1987-97 by seed traders interviewed, Machakos District, Kenya.

	Trend (% entrepreneurs responding)		
Type of change	**Increased**	**Decreased**	**No change**
Price	91		6
Number of suppliers	81	3	9
Seed customers	74	20	3
Profit margins	36	15	42
Packaging practices	23	4	48
Seed availability from suppliers	6	64	21

Conclusions

The evolution of the seed industry in the semi-arid region of Kenya can be divided into several stages of development. Morris et al. (1998) have conceptualized four stages, which represent arbitrarily selected points along a continual growth path. In stage one, there is only local seed and no formalized exchange relationships beyond kinship and other local community networks. Labeled the pre-industrial stage, all the functions of varietal improvement and maintenance, seed production, and distribution are managed through an informal but efficient system. In the second emergence stage, specialized knowledge from research organizations is used to generate open-pollinated varieties (OPVs). In the absence of economic incentives, government agencies assume the functions of research, seed multiplication, and provision. In the third expansion stage, markets are increasingly commercial and hybrids emerge. Private firms now also carry out plant breeding, produce and market seed, and competition helps maintain quality. Stage four is the maturity stage where private firms take over functions previously performed by the state. This model represents the evolution of the seed sub-sector in the semi-arid districts of Kenya reasonably well. Both the OPV and hybrid maize seed sub-sector feature aspects of stages 1-3. Sorghum and millet seed are still largely OPVs and the seed industries for these crops are at evolutionary stages 1 and 2, as are those for most grain legumes.

The study found that public sector agencies such as KARI, KSC, KEPHIS, and the Ministry of Agriculture played key roles in varietal development, inspection and certification, and in providing extension advice in the area. There have also been NGOs and voluntary agencies operating in the area in recent years. Several international agricultural research agencies, such as ICRISAT, CIMMYT, CIAT, IITA, and public universities work in close collaboration with KARI, relevant government departments, and voluntary agencies to develop, produce, and distribute seed. Other public sector agencies involved in the seed sub-sector are the Kenya Forestry Research Institute, GTZ, Danida, and the Belgian government.

The preferred source of seed for the majority of farmers was their own seed. Other important sources were seed traders and public sector agencies. Farmers' seed management strategy embraced selection of plants in the field. At the time of the survey, just less than one-fifth of respondents had received training in general agriculture and only 5% in seed selection. Improved seed were purchased in March, October, and November, coinciding with the onset of the long and short rainy seasons, respectively. The proportion of farmers who purchased improved seed was low. On average, the quantity of seed purchased was also low.

The seed traders survey indicated that most small businesses in the sample were established after liberalization of trade in agricultural inputs. Typically, these businesses stocked many farm inputs along with seed. Because the amount of seed farmers purchased was modest, seed traders stocked small quantities. Costs were spread over many items. Most traders advised seed buyers on the suitability of seed and how seed of specific varieties should be planted. Given the high quality of personnel manning these businesses, this finding was not surprising. According to seed traders interviewed, the most serious constraints to the expansion of seed trade in the area were the small amounts of seed purchased and stiff competition between suppliers.

Smallholders, as well as large-scale farmers in the area, participated in seed production schemes with varying results. Large farms had higher yields and lower unit costs than small-scale farms, perhaps through exploiting economies of scale. Large farms (e.g., the National Youth Service farm in Yatta, Muka Mukuu, and Tana and Athi River Basin Development Authority farms) could also mitigate the effects of climatic variability by investing in irrigation, seed conditioning, and storage facilities, at lower average cost. The seed producers survey indicated that farmers managed their seed crops better than regular crops and realized higher yields and gross margins for all crops except sorghum. Production costs were dominated by financial outlays on labor, fertilizers, and transportation.

Recommendations

There are specific requirements for seed production—physical characteristics such as weight, volume, color, moisture content, germination levels—and seed health standards should also be met. Seed production involves technical operations such as assembling, processing, labeling, sealing, bagging, packing, and storing. Properly undertaken, these practices will help ensure farmers' access to seed that is true to type, free from pests, diseases, and other foreign matter, and that will germinate well if planted. In general, availability of seed that met these requirements would be beneficial to farmers, seed producers and vendors, and society at large (USDA 1961). However, producing quality seed has cost implications that need to be justified in terms of benefits.

Based on the findings of the surveys, several recommendations are offered. The quantity of seed handled through local trade is low and represents a major constraint to private sector participation in the area. Developing varieties that match farmers' requirements would contribute to increased

demand for seed and improve prospects for private sector entry. Dryland crop breeders should offer farmers a choice between open-pollinated, self-pollinated, and hybrid varieties. The latter, if assessed as superior by farmers, would increase demand for purchased seed.

In addition, training and demonstrations should be organized to build and strengthen farmers' capacity to manage seed on-farm. Techniques transferred to farmers should be based on a sound understanding of local seed management strategies and practices.

Seed production costs and supply prices were high and a major constraint to the development of local seed trade. Further research to reduce production costs and institutional arrangements that can reduce production and distribution costs should also be explored.

The study indicated that the "seed loans" model has been effective in making seed available to many farmers. It is recommended that this approach be pursued and refined. Some aspect of transfer of information on farm-level seed management should be tied to the "loan," and feedback on seed performance should be tied to the "repayment."

The study did not permit data collection for the analysis and modeling of appropriate seed pricing scenarios. An appropriately designed study addressing this shortcoming should be conducted.

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