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Working Paper 98-01

Institutional Change and Discontinuities in Farmers' Use of Hybrid Maize Seed and Fertilizer in Malawi: Findings from the 1996-97 CIMMYT/ MoALD Survey

Melinda Smale and Alexander Phiri,
with contributions from G.A. Chikafa, P.W. Heisey, F. Mahatta, M.N.S. Msowoya, E.B.K. Mwanyongo, H.G. Sagawa, and H.A.C. Selemani

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* Melinda Smale and Paul W. Heisey are with the International Maize and Wheat Improvement Center (CIMMYT), based in Mexico; Alexander Phiri is with Bunda College of Agriculture, Malawi; G.A. Chikafa and F. Mahatta are from Kasungu Agricultural Development Division; M.N.S. Msowoya and E.B.K. Mwanyongo are from Mzuzu Agricultural Development Division; and H.G. Sagawa and H.A.C. Selemani are from Blantyre Agricultural Development Division. The views expressed in this document are those of the authors and do not represent the official policies of their respective institutions.

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Contents

Abstract

This study records the use of hybrid maize seed and fertilizer by small-scale farmers in Malawi, as well as their opinions about these inputs, from 1989-90 through 1996-97. Its main purpose is to determine whether the principal constraint to smallholders' use of maize hybrids is the acceptability of the hybrid maize germplasm or the institutional reforms and policies affecting its use. The study also provides information about a practice that has implications for the impact of seed technologies and seed industries — the recycling of nonconventional hybrids (i.e., saving seed of an F_1 hybrid to plant in subsequent seasons). Findings of the most recent farmer survey in 1996-97 demonstrate that the grain quality or yield characteristics of maize hybrids no longer constrain smallholders' use of F_1 hybrid seed. Farmers stated almost unanimously that they wanted to grow F_1 hybrid seed, but most could not purchase as much seed as they wished. A large number of farmers recycle hybrid seed, which is not surprising, given the early stages of diffusion of hybrid maize in Malawi, the start-stop nature of policies affecting input use, and free seed distributed by the government and NGOs. It may be worthwhile for researchers to investigate prospects for producing hybrids whose characteristics resist deterioration from recycling. Aside from this plant breeding issue, pressing concerns of national maize production, food security, and the welfare of smallholders remain to be addressed. Farmers with the resources to use credit, purchase inputs, grow cash crops, or produce maize surpluses represent a smaller and smaller percentage of farmers. It is doubtful whether complete reliance on private initiatives can transform the smallholder maize sector in a country that relies on agriculture as much as Malawi, but where infrastructure is inadequate, nonfarm employment opportunities are few, and incentives are insufficient to mobilize trade and generate cash in rural areas.

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Acronyms

ADD	Agricultural Development Division
ADMARC	Agricultural Development and Marketing Corporation
ASA	Annual Survey of Agriculture
EA	Enumeration area
MoALD	Malawi Ministry of Agriculture and Livestock Development
MRFC	Malawi Rural Finance Company
NSCM	National Seed and Cotton Milling, previously National Seed Company of Malawi
NSO	National Statistical Office
SACA	Smallholders Credit Association

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Introduction

In research about the adoption of seed-fertilizer innovations in developing countries, it is rarely possible to observe input use among individual farmers over time. Typically a "snapshot" cross-section of farmers serves as a proxy for time, even though the term "adoption" implies the continued use of an innovation by the same farmers. This study provides an opportunity to record the use of hybrid maize seed and fertilizer by small-scale farmers in Malawi, as well as their opinions about the inputs, from 1989-90 through 1996-97. Its main purpose is to determine whether, in present-day Malawi, the principal constraint to the use of maize hybrids by small-scale farmers is the acceptability of the germplasm or the institutional reforms and policies affecting its use.

The period covered by this study spans a major historical juncture in the political economy and social organization of Malawi. During this period, donors and lending agencies have pursued major economic reforms. Public and parastatal marketing boards have been dismantled, and subsidies on the use of purchased inputs and farm credit have been removed. The auction floors for the high-valued burley tobacco crop, previously grown exclusively by estates, have been opened to smallholders. Rhetoric about "democratization" and "decentralization" has assumed daily significance in the lives of Malawians as they cope with the transition from 30 years of government by a single party to a multiparty system. Although the data we have collected do not permit us to assert causal relationships between these fundamental changes in institutions and input use in maize production, they enable us to develop some hypotheses and to record the views of farmers themselves.

Monitoring the adoption patterns of several hundred small-scale farmers in Malawi provides insights that extend beyond that nation's boundaries. This case study plays a role in the more general policy discussion over the prospects for increasing food production in sub-Saharan Africa under structural adjustment programs. Despite scattered success stories about the use of productivity-enhancing technologies in this region, there is evidence that advances in productivity have not kept pace with population growth. Per capita production has stagnated or declined. Jayne, Mukumbu, and Jiriyengwa (1997:235) have concluded that in Eastern and Southern Africa, "contrary to most donor expectations, the removal of government controls on private grain trading generally did not raise production incentives or expand market opportunities for smallholder farmers." In their study of 400 smallholders in five districts of Malawi, Zeller, Diagne, and Mataya (1997) found that current policies provide disincentives to maize production in general and hybrid maize

production in particular. Based on her longitudinal research in the Shire Highlands of southern Malawi, Peters (1996) has argued that market liberalization has provided new opportunities (through tobacco and maize sales) that have disproportionately benefited the better-off households, while the poorest 25% have experienced a relative worsening in income and food security. In a recent analysis of agricultural policies in Malawi, Kherallah and Govindan (1997) concluded that in addition to the sequencing of price reforms, institutional reforms that affect access to credit, delivery of inputs, adoption of technology, and the adequacy of infrastructure are needed to ensure successful market reform.

Malawi's story is unique in several respects. First, the smallholders who have used and continue to want to use (but cannot afford) improved seed in Malawi are some of the most resource-constrained producers in sub-Saharan Africa. Malawi is a small, landlocked nation of about ten million people, and it is one of the ten poorest countries in the world (World Bank 1996). By some estimates, at least 50% of its farmers cultivate less than one hectare, and more than 90% cultivate less than three hectares (House and Zimalirana 1992).[1] Second, although maize became the dominant cereal in Malawi only at the turn of the twentieth century, its contribution to caloric consumption in that nation is one of the highest in the world (FAO data files). Third, a maize breeding innovation — the release of nonconventional hybrids with flint grain texture — has recently fostered a change in smallholders' perceptions about maize hybrids and their use of them.

This study also provides information about a farmer practice that has implications for the impact of seed technologies and seed industries — the recycling of nonconventional hybrids. "Recycling" refers to the practice of saving the seed of an F_1 hybrid to plant in subsequent seasons. As the Government of Malawi, donors, and other organizations take a closer look at alternative forms of economic organization to produce and distribute seed among small-scale farmers, the question of recycling F_1 hybrids may assume importance. The extent of recycling among farmers and their opinions about the practice has been recorded, and in this survey we have related the findings to experimental analyses.

The next section of this paper summarizes findings from the research that preceded this study and discusses the motivation for the research described here. Then we outline the major policy and institutional changes that have occurred in Malawi since that time and discuss their implications for the use of purchased inputs in maize production. After providing some methodological and technical background about the survey instrument and its implementation, we review findings from the 1996-97 survey, with reference to the previous data. In the final section of the paper, we present some conclusions and discuss their implications.

[1] More recent estimates, based on the last national sample survey of agriculture in 1992-93, suggest as many as 48% of smallholders farm less than 0.5 ha (NSO 1996).

Motivation for This Research

Dent grain texture is believed to have limited the popularity of hybrids among Malawi's small-scale farmers for many years (Kydd 1989). With the exception of the hybrid LH11 ("Bingo"), all maize hybrids imported or released by the national maize breeding program between Independence in 1964 and 1990 have had dent grain texture.[2] Malawian farmers who produce maize for consumption prefer flint-textured varieties such as their own "local" maize. Women can process flint maize more efficiently (with less loss of grain) into the fine white flour they use to prepare the staple food, a stiff maize porridge. Farmers and researchers often report that local maize is more resistant to weevils in on-farm storage than maize with dent grain (Smale et al. 1993; Zambezi et al. 1997), although the relationship between grain texture and weevil resistance is not a direct one.[3] Because virtually all of Malawi's small-scale farmers produce maize for consumption as well as for sale, processing and storage performance are key varietal characteristics.

In the late 1980s, the World Bank and other donors pressured the national maize breeding program to develop a maize hybrid with flint grain texture for smallholders. With the support of the Rockefeller Foundation, and in close collaboration with the International Maize and Wheat Improvement Center (CIMMYT), the program released two new semiflint hybrids (MH18 and MH17) in 1990. MH18 and MH17 are termed "nonconventional" hybrids: each is a top-cross between a Malawian hybrid (MH12, which is SR52; and MH16, respectively) with a breeding population from CIMMYT (Population 32).

These relatively early maturing, top-cross hybrids perform well in researcher-supervised demonstrations (Jones and Heisey 1994) as well as in farmers' own evaluations (Smale et al. 1993). Like other Malawian hybrids, they yield well relative to local maize even under low levels of management and fertilizer. Yield was not sacrificed for grain texture: data from the demonstrations in central Malawi suggest a 50-70% yield advantage of the hybrids over local maize, without fertilizer, over 1990-93. Because MH17 and MH18 are top-crosses of a flint population and a dent hybrid, they produce relatively variable, segregating populations compared to other types of hybrids. For this and other reasons, MH17 and MH18 were viewed as a temporary step rather than as a long-term solution to the problem of developing suitable maize germplasm for smallholders.

Combined with other encouraging changes in the supply and distribution of seed – including expansion of the Smallholder Agricultural Credit Administration (SACA) to serve a larger percentage of smallholders, and Cargill's purchase of majority ownership in the National Seed Company of Malawi (NSCM, now National Seed and Cotton Milling) – the

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[2] LH11 ("Bingo") is a semiflint hybrid developed before Independence but released later. For a current description of hybrids released in Malawi, see Zambezi (1997).

[3] According to research presented by J.T. Arnason at the Second Weevil Workshop, 26-28 February 1990, hosted by CIMMYT and sponsored by the International Development Research Centre (IDRC), the factors affecting weevil resistance are grain hardness, sugar content of the grain, moisture content, husk cover, and possibly certain chemical properties of the grain. Flint grain texture, however, is related only indirectly to grain hardness, which is defined as the force required to crack the kernel.

release of these hybrids contributed to rising adoption rates. Although more and more smallholders purchased hybrid seed with cash, a large proportion of those using hybrids were members of SACA credit clubs who received their inputs from, and delivered their outputs through, a parastatal marketing board, the Agricultural Development and Marketing Corporation (ADMARC). Inputs for smallholders were nominally subsidized and the credit and marketing systems were also subsidized and centrally organized. The system functioned effectively in many respects, although it was part of an institutional structure that was generally considered to be discriminatory toward smallholders (Kydd and Christiansen 1982; World Bank 1995).

In June of 1993, Malawians voted to change their government from a single-party system to a multiparty system. Following this historical decision, many other changes occurred in the organization and delivery of inputs. Since then, the percentage of area planted to first-generation hybrids in Malawi has fluctuated from year to year but has never reached the level attained in 1993. The next section reviews the essential features of the policy and institutional environment that have affected the demand for purchased inputs in smallholder maize production between the two study periods.

Recent Institutional and Policy Changes Affecting the Use of Maize Seed and Fertilizer

Policy Reforms

Malawi's economy is "fragile, narrowly based, and lacking in key social services and infrastructure" (Ng'ong'ola 1996:62). Since the early 1980s, its evolution has been influenced by structural adjustment programs supported by the International Monetary Fund (IMF), the World Bank, the US Agency for International Development (USAID), and other donors (reviewed in Sahn, Arulpragasam, and Merid 1990). The 1990s have been marked by major changes, including the implementation of policies designed to encourage the private sector to play a more active role in marketing agricultural inputs and outputs, decontrol of agricultural input and output prices, and the removal of subsidies on agricultural inputs.

In 1987, the government of Malawi liberalized the marketing of smallholder crops, except for cotton and tobacco.[4] Since 1994, smallholders have been permitted to sell their tobacco on the auction floors, as well as to intermediate buyers and ADMARC. Crop prices have been progressively descheduled, although the government currently sets floor and ceiling prices (a price band) for maize grown by smallholders, and its export is still prohibited.

[4] Agriculture in Malawi is usually described as consisting of two subsectors, although the distinctions between them have blurred over the years (Mkandawire, Jaffee, and Bertoli 1990). The smallholder subsector comprises an estimated 1.8 million farm families engaged in subsistence-oriented agriculture on land that is cultivated under a customary tenure system (Ng'ong'ola, Kachule, and Kabambe 1997), accounting for 80% of the nation's food production, 10% of the value of total exports, and 90% of agricultural employment. The major crop grown in this subsector is maize. The estate subsector occupies approximately 9% of the total land area of Malawi on leasehold or freehold tenure, generating nearly 90% of the country's foreign exchange through exports of tobacco, tea, and sugar.

Until the market reforms, inputs for the two subsectors were procured and marketed through separate organizations, and the fertilizer sold to smallholders, unlike that sold to estates, was subsidized. Since 1994-95, any firm may import and sell fertilizer to either smallholders or estates, and in 1995-96, fertilizer subsidies were completely removed. In 1993-94, production and marketing of hybrid maize seed was liberalized; the subsidy on hybrid maize seed was removed a year later.

Before 1993-94, SACA, a government organization established within the Ministry of Agriculture and Livestock Development (MoALD) in 1988, was the only agency involved in supplying smallholders with subsidized credit through farmers' clubs. The SACA issued credit in kind for fertilizer and improved seed, using the ADMARC distribution system. The loan recovery performance (90%) was among the highest in the Third World, partly because SACA strictly enforced the requirement that a farmer group repay its previous loan in full as a condition for a new one. Recoveries dropped to 25% in 1991-92 and to 16% in 1993-94, leading to a total collapse of the SACA credit system. Some of the factors that contributed to its collapse included the breakdown in the credit recovery system, low gross margins for crops, the 1991-92 drought, the decoupling of extension and credit activities, and the fact that politicians used credit as a political instrument during the campaign for the multiparty elections in 1993 (Chirwa 1994).

In 1994, SACA was converted into the Malawi Rural Finance Company (MRFC), a limited liability finance company, reducing the heavy dependence on government support and accelerating privatization of the rural credit system. The MRFC uses market-determined interest rates to ensure availability of credit and adequate profit for the financial intermediary. Over its initial years of operation, MRFC has charged an interest rate that has varied between 36% and 54%, which partly reflects differences in the rates charged by the Reserve Bank to financial institutions (Phiri, Mthindi, and Mazengera 1996).

The MRFC offers two kinds of seasonal agricultural loans. A farmers' group can obtain a loan without collateral under the *Mudzi Tikolore* scheme, given a six-month training, savings, and waiting period. The collateralized seasonal agricultural loans require an immediate payment of a minimum of 10% and a title deed to the farmer's land as security. If the borrower does not hold title to the land, then he/she must belong to a farmers' club and must have undergone a six-month training and waiting period to qualify for the loan. For most smallholders in Malawi, these requirements are prohibitive.

Other formal sources of credit available for smallholders include: Smallholder Crop Authorities, which provide funds to obtain inputs for their particular crops (coffee, tea, sugar, and tobacco); Malawi Union of Savings and Credit Cooperatives (MUSCCO); Promotion of Micro-Enterprises for Rural Women (PMERW); and the Tobacco Association of Malawi (TAMA), which loans money primarily for tobacco production. Unlike estate farmers, smallholders do not rely on commercial banks for credit, probably because of the conditions attached to the loans.

None of the formal credit sources provides credit for maize production unless the farmer is producing another cash crop, yet the informal credit market for agricultural inputs is very poorly developed (Diagne, Zeller, and Mataya 1996). Malawi's experience seems to support the argument made by Aryeetey (1996) that the current paradigms of financial market liberalization and directed credit have proved inadequate for addressing the structural and institutional constraints on Africa's financial markets.

The Diffusion Path for Hybrid Maize

Figure 1 shows the diffusion curve for hybrid maize seed in Malawi over the time period spanning these changes. Two aspects of the curve are particularly noticeable. The first is its shape. The percentage of maize area planted to hybrid maize stagnated at under 10% from 1980 through 1987.[5] This percentage rose steeply from about 1987 through 1993, the year when SACA collapsed, but has fluctuated widely since then. In 1994, which was also a very poor crop year, all nominal input subsidies were removed. In 1995, a poor crop year, and in 1996, a bumper crop year, the government and nongovernmental organizations (NGOs) gave F_1 seed to smallholders (much of it bought from NSCM carryover stocks). In 1996-97, no free seed was distributed, no subsidies were in effect, and no formal credit system provided credit to smallholders for maize production (some NGOs provide seed for credit, but with limited coverage).[6]

The second important aspect of the diffusion path is its increasing "fuzziness": area estimates based on commercial seed sales now diverge from those developed in the national crop estimates. There are three possible explanations for this divergence. The first, and probably the most important, is the use of advanced-generation hybrid seed. Especially when they are observed in early vegetative growth in farmers' fields, plants of recycled top-cross hybrids may not be easily distinguished from hybrids planted for the first time. The field staff responsible for providing crop estimates may be reporting areas for both first- and advanced-generation hybrid seed. A second explanation is that farmers occasionally save seed that was purchased or obtained in a free distribution and plant it in the next season — particularly when the seed is obtained after the best planting period. This occurs frequently with free seed distribution programs. A third explanation

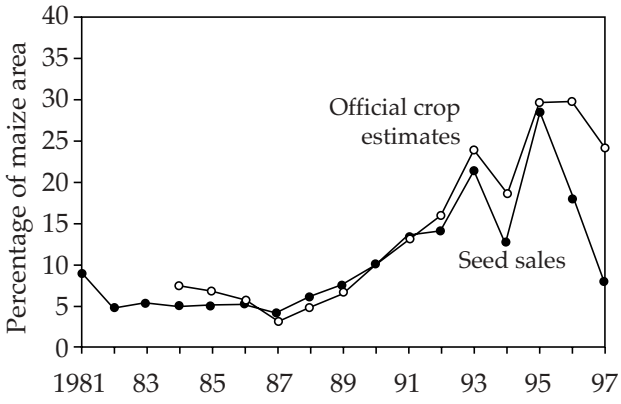

Figure 1. Diffusion of hybrid maize seed among smallholders, Malawi, 1981-97.
Source: NSCM, MoALD.

[5] Only anecdotal evidence is available for the period (see Kydd, 1989) preceding the 1980-81 National Sample Survey of Agriculture, but few hybrids were available for smallholders during that period. The hybrid maize breeding program was discontinued from 1967 to 1977, and small quantities of the hybrid SR52 were imported from Zimbabwe for estate farmers.

[6] The free fertilizer and seed distributions that have been a feature of government/donor policies in the 1990s may well continue. In the 1997-98 season, for example, the European Union will sponsor a distribution of F_1 hybrid maize seed, fertilizer, and grain legume seed.

is cross-border movement of seed. The Zambian maize hybrid MM604, for example, is very popular in parts of Malawi because of its early maturity.

Hybrid Seed Prices and Profitability

Is commercial hybrid seed profitable? In partial budget analysis of demonstration data from 1989 through 1993, Jones and Heisey (1994) concluded that the semiflint hybrids were profitable for smallholders under several pricing scenarios and management environments, even without nominal subsidies — although not always with recommended levels of fertilizer. The full effective subsidy of the smallholder credit and ADMARC delivery system is difficult to measure, however, so the impact of its dissolution on the real returns faced by farmers was incompletely captured in that analysis.

Is the seed price "right"? MH18 is a top-cross and NSCM41[7] a three-way cross. National Seed and Cotton Milling has a large fixed plant and operates with large risk premiums. The seed-to-grain price ratio has been rising steadily since 1989 and has ranged between 7 and 12 since 1993, depending on the type of hybrid (lower for the top-crosses) (Figure 2). Analysis of cross-sectional historical data of seed industries in developing and developed countries indicates that initial widespread adoption of hybrid seed is typically associated with a seed-to-grain price ratio of 10 or below. When a seed industry is mature, ratios of up to 30-40 do not seem to dampen sales of hybrid seed, but in a nascent industry such as Malawi's, a ratio of 5 or below is most conducive to growth in adoption (Heisey et al. 1998).

Byerlee, Morris, and López-Pereira (1993) have estimated the seed-to-grain price ratios and yield advantages necessary to repay the additional cost of hybrid seed and generate a 100% marginal rate of return for farmers at various yield levels. The 100% marginal rate of return is intended to cover the costs of learning and other transactions that smallholders face, especially in the early years of adopting a technology. At the average yield of 1 t/ha in Malawi, a seed-to-grain price ratio of 10 would require a yield advantage of 40-50%, which is less than that reported above for unfertilized hybrid maize in the Central Region but may be above what can be attained by smallholders in other, less favorable, environments.

Is it possible to reduce the seed-to-grain price ratio to a range that is more favorable for smallholders? Most seed industry experts believe that production of F_1 hybrids by farmers is far less likely to succeed than their production of improved open-pollinated varieties (OPVs) because of the labor, management, and certification

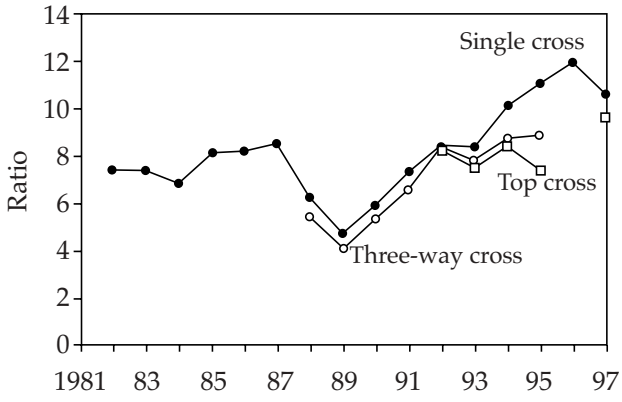

Figure 2. Hybrid maize seed-to-grain price ratio, Malawi.
Source: ADMARC, MoALD.

[7] NSCM41, though dent in grain texture, has been a very popular maize hybrid among smallholders and estate owners in part because of its early maturity.

requirements. Opportunities for farmer production of both improved OPV and hybrid seed are currently being explored by the government of Malawi and donor organizations (G. Luhanga and E. Sibale, pers. comm.).

The structure and institutional framework of the seed industry also have implications for the nominal and effective (including transactions costs) seed price faced by farmers. Although a number of key steps have been taken toward "liberalization" of the seed industry,[8] one transnational company still dominates seed production and distribution in Malawi, and the absence of medium-sized or small, family-operated enterprises is noticeable. In a 1995 report on the retail trade in agricultural inputs, Tsoka concluded that current and planned policy, legislative, and regulatory frameworks are not conducive for retailers' participation in the marketing of agricultural inputs. He found that (1) marketing arrangements of many private companies were not favorable for rural farmers because they concentrate their outlets in urban areas; and (2) the government's policy on liberalization of agricultural marketing has not extended to all agricultural inputs and potential retailers. He also noted that farmers even had problems obtaining inputs from ADMARC markets, because stocks were not always of the quantity, type, and size demanded by farmers.

Fertilizer prices and profitability also influence farmers' choice of seed. Many farmers still believe that hybrid seed "requires" fertilizer, although since market liberalization seed and fertilizer can be purchased separately and in variable amounts rather than in packages of fixed proportions. At current fertilizer-maize price ratios and levels of nutrient response, fertilizer use (at any level of application) is unprofitable for commercial production by smallholders in many maize-growing areas, although it is profitable in production for home consumption *if* the household has other cash-earning activities to finance the purchase (see full analysis by Maize Productivity Task Force, 1997; Whiteside and Carr 1997). Fertilizer-maize price ratios have risen sharply over the past two seasons for several reasons: (1) subsidies have been removed; (2) the devaluation of the Malawi kwacha (MK) boosted fertilizer prices disproportionately to maize prices; (3) world fertilizer prices have risen (probably temporarily); and (4) private fertilizer dealers are requiring substantial risk premiums to hold and transport fertilizer in an inflationary economy with uncertain demand (Heisey and Benson, pers. comm.; related policy issues and options are discussed in Conroy, 1997).

Obviously the grain price also affects the profitability of input use on maize. In general, the maize producer price in Malawi has followed and continues to follow the export parity price. If the MK is still overvalued, as current inflation rates suggest, most recent maize producer prices may be below export parity. Because Malawi in most years is either an importer or self-sufficient in maize, the price should range between import parity and export parity, at the minimum. Because in the near future Malawi will rarely export maize, the maize price should rise.

[8] In 1994, Chakravarti recommended, among other steps, the elimination of the seed subsidy, termination of the exclusive marketing agreement between ADMARC and NSCM, relaxation of seed import controls, and revision of variety release procedures. All of these steps have been accomplished.

The greatest underlying problem affecting the use of hybrid seed and fertilizer today may not be the input-output price ratio or the profitability of the technology, but cash flow and the continued erosion in the effective purchasing power of rural households following successive devaluations, inflation, and other macroeconomic changes.[9] Declining purchasing power in turn curbs the upward pressure on maize prices. In her longitudinal study, Peters (1996) has documented that when the majority of farmers purchase maize because they are unable to produce enough to meet their requirements, rising maize prices will result in a greater portion of the harvest retained rather than in a greater proportion sold. By retaining more maize, selling more labor, and increasing the budget share of purchased maize, the poorest quartile of the households in her study suffered a decline in food security.

Methods

Analyzing Constrained Decisions in Farmers' Use of Seed

The conceptual approach developed by Diagne (1996) for analysis of credit constraints also provides a framework for analyzing seed supply and demand issues and how they affect farm household decisions. In this approach, it is the extent of a constraint at the time the input is sought by the farmer, rather than the existence of a constraint (usually termed *access*), that matters. The supplier of an input chooses the amount he or she is willing to supply and at what price. Related institutions determine further transactions costs and quality issues. The relationship between access and rationing is depicted in basic mathematical terms in Table 1. B_{max} is the maximum amount of an input that the seed industry can make available to a farmer at time t, at supply price p. The farmer price is $p^* > p$, by the amount of transactions costs. B* is the amounted demanded by the farmer.

Table 1. Relationship between access and rationing

Seed supply-demand relationship	Type of farmer-user
$b_{max} > 0$	Has access
b^* is constrained to 0 because $b_{max} = 0$	Has no access
$b^* = b_{max} > 0$	Unconstrained
$0 < b^* < b_{max}$	Unconstrained
$b^* > b_{max}$	Rationed
wants $b^{**} > b^*$, but demands $0 < b^* < b_{max}$, because believes it is not possible to obtain more[a]	Discouraged

[a] In the case of credit, discouraged users are individuals who do not apply for a loan because they believe they will be rejected (Zeller et al. 1996; Jappelli 1990).

[9] Under the previous institutional regime, when prices of hybrid seed, fertilizer, and maize were supported and more closely regulated, input delivery was heavily subsidized through the smallholder credit system and ADMARC, and burley tobacco could not be grown by smallholders, the use of hybrid seed by smallholders was sensitive to prices and cash flow. At that time, however, the use of fertilizer on local maize did appear responsive to prices and cash flow (Smale, Heisey, and Leathers 1995:365).

In our study, we have sought to identify these subgroups for both use of credit and use of F_1 hybrid seed.[10] Based largely on this type of framework, we adapted a decision tree diagram for the credit use decision (Zeller et al. 1996:47) for this study (Appendix A). Decision tree analysis has been used in studies of farmers' adoption decisions by Gladwin (1979), Franzel (1983), and Kelly (1988), among others. Orr (forthcoming A) has also used it to relate the use of hybrid maize seed and fertilizer to production of burley tobacco. Our use of the logical trees is principally as an aid to policymakers in identifying which constraints, among the several types of constraints that affect farmers' decisions to plant maize hybrids, were likely to have been binding in the 1996-97 planting season.

Survey Methods

During the 1989-90 and 1990-91 cropping seasons, CIMMYT and MoALD implemented a maize variety adoption survey in three of the five major maize-producing Agricultural Development Divisions (ADDs) of Malawi. The three ADDs (Blantyre, Mzuzu, and Kasungu) have contrasting agroecological and socioeconomic characteristics and constituted the strata for the survey. In each ADD, seven enumeration areas were selected from the sampling frame designed by the National Statistical Office (NSO) for the Annual Survey of Agriculture (ASA). From each enumeration area, a 10% sample of 20 households was drawn from the listing of all households. Households have an equal probability of selection within each of the three zones and varying probability of selection between zones. These probabilities are accurate to the extent that the distribution of population within the zones has remained constant over time. Here, all aggregated figures for the combined survey zones are reported based on probabilities used in the original survey.[11]

The survey instrument for 1989-90 and 1990-91 included a supplementary schedule on maize varieties that was attached to the questionnaires and plot schedules of the ASA. Enumerators were professionals who resided in the village, implementing the survey in multiple visits during the cropping season. Areas were measured directly by plot. Enumerators were joined in their farmer visits repeatedly during the cropping season by supervisors from the ADD and by the CIMMYT investigator. The results of this survey were reported in Smale et al. (1991) and related publications.

After the initial two-year survey period, CIMMYT, NSCM, and MoALD initiated a Farmer Evaluation Survey. Five-kilogram packets of hybrid maize seed were distributed to all participating survey farmers in 1991, and three enumeration areas (EAs) in each survey zone were purposively selected for evaluation. Each farmer in these EAs was given a combination of dent hybrid and semiflint hybrid types, without fertilizer, and asked to manage them

[10] Diagne adds that informal markets complicate this approach because the household's demand for credit cannot be modeled separately from its supply — the decision over supply becomes endogenous. In the literature about credit constraints, Jappelli's analysis (1990) is cited as a rather unique example in which the various types of constrained borrowers (discouraged, rationed, and rejected) could be identified separately in the data and their characteristics compared. In their analysis of credit and productivity in Chinese agriculture, Feder et al. (1990) were also able to identify households demanding more credit than the amount they obtained (rationed, constrained users), households that did not borrow because they were denied credit (rejected, constrained users), and households that did not seek credit because they had other and sufficient funds (unconstrained nonusers).

[11] Appropriate weights are the inverse probability of selection divided by the sum of the inverse probabilities of selection for all strata, equaling 0.375 for Blantyre, 0.179 for Mzuzu, and 0.446 for Kasungu.

under his or her own conditions. Enumerators then asked the farmers to rank the hybrids with respect to yield, pounding quality, storage quality, and other characteristics. These findings were summarized in Smale et al. (1993).

The 1996-97 survey was far less detailed and was implemented in two stages: (1) household listing and verification; and (2) administration of the questionnaire. With a few exceptions, the enumerators and supervisors had worked with the farmers previously. They could identify the farmers, understand detailed information about maize varieties, and judge the validity of farmers' responses. Responses with respect to the varieties grown in each year between the survey periods were based on recall. Most farmers had little difficulty recalling the varieties they had grown because of the central importance of maize production in their activities. When they were initially contacted for the 1996-97 survey, farmers were asked to note how much seed they planted and save the bag or identify the container they had used for their seed. Area figures reported here were derived from farmers' responses, based on usual weights for standard pails or weights that were calculated using scales, assuming a seeding rate of 25 kg/ha for all seed types.

Between 1989-90 and 1996-97, the sample of farm households was reduced by migration, marriage, and death from 420 to 349 households (by about 20%). Only when an entire household had moved from the EA in search of employment or as a consequence of the death of family members was it excluded from the sample. When a head of household died but the household remained in the EA, when a migrant head of household returned, or a head of household changed through marriage, the household remained in the sample.

Survey Findings

The major characteristics of the survey zones and farmers are summarized in Appendix B, based on the descriptive data reported in Smale et al. (1991).

Use of Maize Seed

The percentage of survey farmers planting seed of local maize, improved OPVs, F_1, and advanced-generation hybrid maize is shown in Figure 3, for all survey zones, for the cropping seasons from 1989-90 through 1996-97. In each year, percentages total to more than 100 because most farmers who plant hybrids or improved OPVs also plant local maize. Distributions of free hybrid seed particularly affected the figures for 1991-92, 1994-95, and 1995-96. In the 1991-92 season, as explained previously, all survey farmers were given 5 kg of hybrid maize

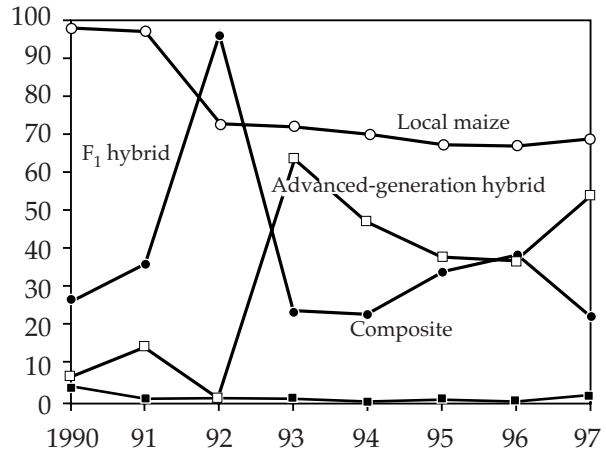

Figure 3. Percentage of farmers growing local, composite, and hybrid maize seed, Blantyre, Kasungu, and Mzuzu Agricultural Development Divisions, Malawi, 1990-97.
Source: CIMMYT/MoALD survey data. See Appendix Table C1 for data by ADD.

seed, of different types, and a subset of these farmers participated in the Farmer Evaluation Survey. Nearly 100% of survey farmers planted hybrid seed in that year.[12] In 1994-95 and 1995-96, some survey farmers received free F_1 hybrid seed distributed by the government or NGOs. Higher percentages of farmers grew F_1 hybrids seed in these years, and the percentage of farmers planting advanced-generation hybrid seed was also higher in the years following distributions. Except for these years, each year between 22% and 36% of farmers in the three zones planted F_1 hybrid seed.

Figure 3 shows a general decline in the percentage of farmers growing local maize and an increase in the percentage growing advanced-generation hybrids. In 1990 and 1991, almost 100% of survey farmers grew local maize. Six years later, slightly over two-thirds grow it — fewer in Kasungu than in Blantyre or Mzuzu. In 1990 and 1991, some advanced-generation hybrid seed was identified in the surveys, but in each year since 1993, between one-third and two-thirds of all sample farmers appear to have grown it. First-generation and advanced-generation hybrid seed has essentially replaced local maize for some survey farmers, but less so in the Mzuzu zone, where the percentage of farmers using F_1 seed has dropped dramatically except in years of free seed distributions (Appendix Table C1).

The percentage of aggregate maize area planted to F_1 hybrid seed has fallen in Mzuzu from 22% in 1990 to only 6% in 1997, although it has changed less in Blantyre and Kasungu (Table 2). While local maize has represented a fairly constant three-quarters of all maize area in Mzuzu, it represents a much smaller share of maize area in the other two survey zones. Advanced-generation hybrid seed represents a much larger percentage of maize area today (30%) than in the earlier survey period (12%). The average area planted by survey farmers to local maize was significantly lower in 1997 than in 1990, while the average area planted to advanced-generation hybrid seed was significantly higher[13] (Appendix Table C2). Only in Mzuzu has the mean area planted to F_1 hybrids by farmers who grow it decreased. Area estimates therefore confirm that farmers are substituting advanced-generation semiflint hybrids for local maize, because of their similar consumption characteristics.

Use of improved OPV seed has been difficult to track in any of the years covered by this research, although enumerators questioned farmers carefully about advanced-generation as well as first-generation improved OPVs. Only a few survey farmers appear to have grown improved OPV seed over 1990-97.[14] Most of the hybrid seed grown by survey farmers in the 1990 and 1991 seasons was NSCM41, MH12, and R201. From 1992, MH18 accounted for an increasing proportion of both F_1 and advanced-generation hybrid seed, with some MH17. MH12, R201, and MH16 have gradually disappeared. This season, MH18 was the most widely grown hybrid among survey farmers, followed by NSCM41. The new varieties NSCM51 ("Chitute") and Kaswiri 64, and the Zambian variety MM604, were also grown by a few farmers.

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[12] Others may have saved the seed for the following year, given it away, or sold it.

[13] As noted earlier, enumerators measured areas directly in the first two seasons. In 1997, estimates were based on farmers' recall of the seed quantities they planted (by unit of measure, converted to kilograms of seed). We then assumed 25 kg/ha of seed for all seed types.

[14] The national crop estimates also indicate that F_1 improved OPVs represented at most 2-3% of total maize area from 1990 through 1996 (unpublished data, MoALD). The varieties UCA, CCA, CCD, and, in the 1996-97 survey, Matupe, were grown by survey farmers.

Recycling of Hybrid Maize Seed

Several recent studies have commented on farmers' practice of recycling hybrid maize seed in Malawi. Based on a study they conducted in Lilongwe ADD, Wright and Tyler (1994:28) reported that "some of the farmers growing the new top-cross hybrids MH17 and MH18 are recycling the seed and are happy with the yields derived from the F_2 generation." In another study, Wright et al. (1995:19) state that the improved varieties grown by the farmers they surveyed were advanced-generation hybrids.

In the first CIMMYT/MoALD surveys of 1989-90 and 1990-91, several farmers growing recycled hybrid maize seed also explained that they were satisfied with the yields they obtained with once- or twice-grown hybrid seed. NSCM41 was then widely grown, and MH18 and MH17 had only recently been released. In the 1996-97 season, the advanced-generation hybrid seed grown by survey farmers had been recycled an average of 2.6 seasons, with a range of one to six years. Most of this seed was MH18, and some of it was NSCM41.

Analysis of experimental data provides some indication of the effects of recycling practices on yield and economic return by type of improved germplasm (Zambezi et al. 1997; updated from Kumwenda, Kabambe, and Sakala 1996). MH17 and MH18 yielded much

Table 2. Percentage of maize area planted by maize type, Malawi, 1990, 1991, and 1997

	Agricultural Development Division			
Year and maize type	**Blantyre**	**Kasungu**	**Mzuzu**	**All**
1990				
Percentage of aggregate maize area in survey zone planted to:				
Local maize	92	84	74	85
F_1 hybrid maize	6	13	22	12
Advanced-generation hybrid maize	1	2	2	2
Composite maize	1	1	2	1
1991				
Percentage of aggregate maize area in survey zone planted to:				
Local maize	85	67	79	76
F_1 hybrid maize	11	23	19	18
Advanced-generation hybrid maize	3	9	2	5
Composite maize	1	1	0	1
1997				
Percentage of aggregate maize area in survey zone planted to:				
Local maize	70	46	72	60
F_1 hybrid maize	7	15	6	10
Advanced-generation hybrid maize	21	40	22	30
Composite maize	2	0	0	1

Source: CIMMYT/MoALD survey data.
Note: "Year" refers to year harvested. "All" category is weighted by probability of selection. Advanced-generation hybrids include mixtures of local and recycled hybrid maize.

more than either local maize or CCC (an improved OPV) at all levels of nitrogen in both the second and third generations. Further, the yield loss due to inbreeding depression was lower for the top-cross hybrids (MH17 and MH18) than for the single-cross hybrids (MH12 and MH16) or the three-way crosses (NSCM41). Recycling had little effect on grain texture. Economic analysis suggested that recycled top-cross hybrids had higher marginal rates of return than CCC or local maize. Higher levels of nitrogen were associated with lower yield losses in recycling.

Analysis of experiments with Zimbabwean materials has demonstrated large declines in yield with three-way cross hybrids, especially under the lower input levels and management regimes representing those of smallholder farmers. In the Zimbabwean experiments, the yields of recycled three-way hybrids were as low or lower than the yields of adapted OPVs (Waddington, Karigwindi, and Chifamba 1996).

In Malawi, farmers' opinions regarding recycling reveal that farmers perceive differences in the effects of recycling by characteristic. Over all of the survey zones, 70% of farmers reported that maize yields declined with years of recycling, 52% reported that germination worsened, 48% reported that storage quality declined, and only 18% reported reductions in pounding quality. The majority of farmers have experienced yield losses associated with recycling, although a number of survey farmers also stated that yield did not decrease if "enough" fertilizer was applied — which parallels the findings of the Maize Commodity Team. Several farmers suggested that careful seed selection could help sustain yields and germination quality.

The majority of farmers did not experience a decline in pounding quality with recycling of hybrid seed. In the Farmer Evaluation Survey, farmers ranked MH18 the same as local maize for pounding quality and NSCM41 inferior to both. If pounding quality remains constant or improves with recycling in either of these hybrids, it may be the result of cross-pollination with local maize or, more likely, farmers' seed selection practices. Without selection, the top-cross hybrids would segregate for grain texture in successive generations. Essentially, farmers may be selecting a flint OPV from the segregating populations. Farmers' responses in 1997 regarding storage quality are mixed, as they were in the Farmer Evaluation Survey, when even F_1 MH18 seed was ranked lower than local maize for resistance to weevils in storage. This result probably reflects the indirect relationship between flint texture and weevil resistance.

The prevalence of recycling practices raises a well-known issue about whether crop improvement programs whose clientele are small-scale farmers should emphasize the development of improved OPVs or hybrids (for evidence of the practice in Zimbabwe, see Chiduza, Waddington, and Mariga 1994). If F_2 hybrids still show significant yield advantages over traditional varieties *as well as improved OPVs*, or if they have other characteristics that farmers value and that cannot be found in other maize types, perhaps the practice of recycling hybrid seed should not be viewed so negatively. Farmers may still receive welfare benefits through recycling, although it provides no benefit to commercial seed producers and is rarely recognized as contributing to research impact. The findings also have implications for which type of hybrid may be most suitable for farmers producing maize in an economic environment similar to that described in this study.

Discontinuities in Seed Use

Recycling is one expression of discontinuities in individual farmers' use of F_1 seed. Other indicators are shown in Table 3. From 1990 to 1997, farmers were able to grow F_1 hybrids an average of only two to three out of eight cropping seasons. Only 7% were able to purchase F_1 hybrid seed every year. Local maize was also grown discontinuously over the period, because in some seasons many of the survey farmers substituted the F_1 or advanced-generation semiflint hybrids for local maize.

Discontinuities do seem to have worsened over 1993-97 relative to the period from the late 1980s to 1993. In the earlier survey, farmers' had an average of only two years of experience with hybrid maize seed, and Mzuzu farmers had the longest experience among the farmers in the three zones. Less than one-third of farmers in Blantyre and about two-thirds of farmers in Kasungu and Mzuzu survey areas had grown hybrid maize in 1990. Of those who had grown it, 20-30% had grown it continuously.

The earlier survey period provided an initial glimpse of these discontinuities and their cause (Smale et al. 1991). At that time we reported that the reasons most frequently cited by Blantyre farmers for ceasing to grow hybrid maize were susceptibility to weevils and money problems. In Mzuzu and Kasungu, farmers most frequently cited credit default, absence of the household head, and low yields. Complaints of low yield and weevil damage are associated with the germplasm and its performance under farmers' conditions and imply that the farmer does not want to continue planting the seed type (in that survey, a dent hybrid). The other issues are related to discontinuities in use but do not imply that the farmer has rejected the germplasm.

Table 3. Discontinuities in use of hybrid maize seed, Malawi

	Agricultural Development Division			
	Blantyre	**Kasungu**	**Mzuzu**	**All**
From 1990 to 1997				
Mean number of years farmers grew:				
Local maize	6	5	7	6
F_1 hybrid maize	2	4	3	3
F_1 or advanced-generation hybrid maize	6	6	6	6
Percentage of farmers having grown hybrid maize	100	100	100	100
Percentage of farmers continuously growing:				
Local maize	54	42	72	52
F_1 hybrid maize	1	12	6	7
Advanced-generation hybrid maize	0	0	0	0
Before 1990				
Mean number of years farmers had grown hybrid maize	1	2	3	2
Percentage of farmers having grown hybrid maize	27	71	61	53
Percentage of those having grown hybrid maize who grew it continuously	24	22	31	24

Source: CIMMYT/MoALD survey data

Note: "Year" refers to year harvested. "All" category is weighted by probability of selection. Advanced-generation hybrids include mixtures of local and recycled hybrid maize.

Use of Fertilizer on Maize[15]

For many years, more small-scale farmers have used fertilizer on maize than have used improved seed (Table 4; Smale et al. 1991). Table 4 shows that over all survey zones, from 1990 to 1997, the percentage of farmers using fertilizer in maize production ranged from 45 to 65, with a slightly lower range of percentages in Blantyre than in Kasungu and Mzuzu. No trend is perceptible in the percentage of farmers using fertilizer on maize, although the quantities of fertilizer applied are likely to have changed.

The distribution of fertilizer use across maize types seems to have varied over time, but in 1997, as in 1990 and 1991, F_1 hybrid maize was almost twice as likely to be fertilized as local maize (Figure 4; Appendix Table C3). A large drop in the percentage of farmers fertilizing F_1 hybrids occurred in 1992, when evaluation packets of F_1 seed were distributed to all farmers without fertilizer, and again in 1993, when SACA collapsed. In 1993, local maize and advanced-generation hybrids were at least as likely to be fertilized as F_1 hybrid seed. From 1994 to the present, in each survey zone, farmers have fertilized advanced-generation hybrid seed with roughly the same frequency as local maize.

Use of fertilizer on maize has also been discontinuous (Table 5). Less than one in five survey farmers used fertilizer in maize production continuously from 1990 to 1997. This percentage is clearly lower than it was prior to 1990. A surprising finding is that the mean number of years in which farmers have applied fertilizer to advanced-generation hybrids is actually greater than the number of years they have applied fertilizer to F_1 hybrids or local maize. This finding may reflect the fact that the survey farmers have grown advanced-generation hybrids more often during these years than F_1 hybrids, and in some cases, more often than local maize. Farmers may also have sought to offset yield declines in advanced-generation hybrids with fertilizer.

Table 4. Percentage of farmers using any fertilizer on maize, Malawi, 1990-97

	Agricultural Development Division			
Year	**Blantyre**	**Kasungu**	**Mzuzu**	**All**
1990	44	60	66	55
1991	61	69	62	65
1992	45	62	60	55
1993	37	49	52	45
1994	40	51	45	46
1995	37	63	50	51
1996	48	60	48	53
1997	37	56	59	49

Source: CIMMYT/MoALD survey data.
Note: There is no statistically significant trend in any of the four series. "Year" refers to year harvested. "All" category is weighted by probability of selection.

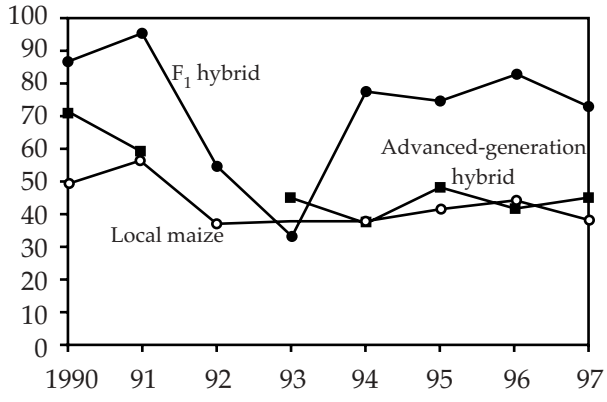

Figure 4. Percentage of farmers applaying fertilizer, by maize type, Blantyre, Kasungu, and Mzuzu Agricultural Development Divisions, Malawi, 1990-97.
Source: CIMMYT/MoALD survey data. See Appendix Table C3 for data by ADD.

[15] Because of timing and other logistical constraints, detailed information on fertilizer application levels could not be collected in the 1996-97 survey as in the 1989-91 surveys.

Sources of Seed

National Seed and Cotton Milling expected to sell 3,000-4,000 metric tons (t) of hybrid maize seed in 1996-97 but sold only 2,200. Together with an estimated 300 t sold by Pannar, total commercial sales of F_1 seed in 1996-97 were approximately 2,500 t. Hybrid seed was distributed to retail outlets in trading centers, gas stations, and farm suppliers. These included the People's Trading Company (PTC), Kandodo, Chipiku, ADMARC, Oilcom, McConnell, and Farmer's World.

Where did survey farmers buy their seed? Few obtained their F_1 hybrid seed with credit, and of these, most received it through NGOs (Table 6). Many obtained their F_1 seed as a gift from relatives or friends, or as a carryover of free seed issued in the previous season. Farmers purchased their seed from a range of retail sources, although ADMARC remains the major source of seed. The local market and other farmers were a minor source of purchased (and resold) F_1 seed. Farmers reported obtaining some very low prices for "F_1" seed on the local market and from other farmers (Table 7).

In 1996-97, by far the major source of local maize seed and seed of advanced-generation hybrids was farmers' own stored seed, although there is local a market for both seed types and the exchange of labor or seed for other seed also occurs. Although relatively few households (only 18%) purchased local or advanced-generation hybrid seed, the estimate we have of their average prices shows some similarity — between 2 and 3 MK/kg (Table 7).

Constraints on the Demand for F_1 Hybrid Seed among Smallholders

The primary motivation for the 1996-97 survey was to determine whether the characteristics of the germplasm or liquidity constraints are currently the foremost constraint on small-

Table 5. Discontinuities in use of fertilizer on maize, Malawi

	Agricultural Development Division			
	Blantyre	**Kasungu**	**Mzuzu**	**All**
From 1990 to 1997				
Mean number of years all farmers applied fertilizer to:				
Local maize	2	3	3	3
F_1 hybrid maize	2	3	2	2
F_1 or advanced-generation hybrid maize	5	5	6	5
Percentage of farmers having used fertilizer	80	94	92	88
Percentage of farmers using fertilizer continuously	15	12	22	15
Before 1990				
Percentage of farmers having used fertilizer	58	83	85	74
Percent of those having used fertilizer who used it continuously	31	25	35	29

Source: CIMMYT/MoALD survey data.

Notes:"Year" refers to year harvested. "All" category is weighted by probability of selection. Advanced-generation hybrids include mixtures of local and recycled hybrid maize.

scale farmers' demand for hybrid seed. The release of MH18 and MH17 was largely a response to evidence that dent grain texture was a principal constraint to the use of hybrids by smallholders in Malawi. Although survey farmers did not contradict this view in 1990-91, they indicated that other factors were also important.

Table 6. Farmers' sources of maize seed, Malawi, 1997

Seed type and source	Agricultural Development Division			
	Blantyre	Kasungu	Mzuzu	All
	percent farmers			
Local maize seed	100	100	100	100
On-farm storage	83	91	84	87
Purchase	10	7	2	7
Gift	5	1	12	4
In exchange for farm labor	2	1	2	2
F_1 hybrid maize seed[a]	141	109	123	124
Gift	36	15	57	30
Purchase	105	79	57	85
ADMARC	–	–	–	50
Other retailers or local market	–	–	–	30
Other farmers	–	–	–	5
Credit	0	15	9	9
MRFC	–	–	–	1
NGOs	–	–	–	7
Retailer	–	–	–	1
Advanced-generation hybrid seed[a]	104	100	110	103
On-farm storage	–	–	–	80
Purchase	–	–	–	11
Gift	–	–	–	7
In exchange for farm labor or seed	–	–	–	5

Source: CIMMYT/MoALD survey data.
Note: "Year" refers to year harvested. "All" category is weighted by probability of selection. Advanced-generation hybrids include mixtures of local and recycled hybrid maize.
[a] Totals to more than 100 because farmers grow more than one type of hybrid.

Table 7. Farmers' seed prices (MK/kg), Malawi, 1997

Seed type	Agricultural Development Division			
	Blantyre	Kasungu	Mzuzu	All
Local maize	2.33	2.10	2.03	2.17
F_1 hybrid maize	16.65	15.60	15.24	15.93
Advanced-generation hybrid seed	2.8	2.07	2.23	2.37

Source: CIMMYT/MoALD survey data.
Note: Differences among mean prices by ADD are not statistically significant. "Year" refers to year harvested. "All" category is weighted by probability of selection. Advanced-generation hybrids include mixtures of local and recycled hybrid maize.

Figure 5 demonstrates convincingly that germplasm was not the major constraint to smallholders' use of maize hybrids in 1996-97. Given their experience, survey farmers almost unanimously stated that they wanted to plant F_1 hybrid maize seed in 1996-97. Of the 4% who said they did not, several stated they liked to recycle hybrid seed for several years. Others explained that they would not grow F_1 hybrids without fertilizer, and several widows stated that they didn't believe they could manage it. Only three farmers complained of low yield, pounding, or storage quality with the Malawian hybrids that are currently available to them.[16]

Despite the strong endorsement of MH18 in particular, only 6% of farmers stated that they had the cash to purchase *as much seed as they wanted.* In terms of the framework we developed earlier in this paper, we can classify 90% of the survey farmers as constrained in the choice of seed or seed-rationed. In other words, these farmers would have liked to plant F_1 hybrid maize but (1) could not find the seed, (2) found the seed but could not buy any, or (3) bought some seed and would have liked to buy more.

Most farmers said that seed was available within a distance that was not prohibitive in terms of the time costs of walking or the costs of obtaining transport. Only a small percentage claimed that obtaining seed in their locality was a problem, and these were found in Mzuzu.[17] For traders, it may not be profitable to transport maize seed into many localities because of sparse populations; similarly, it may no longer be profitable to produce a marketable surplus of grain if there are no traders to buy grain and transport it out of the area. Many of the dirt roads serving the Central Mzimba villages in which the survey farmers live have deteriorated.

The overwhelming majority of farmers (71%) did not plant any F_1 seed because of cash constraints, and 16% planted some but would have liked to have planted more. This means that although 22% of all survey farmers planted some F_1 seed, a large proportion of these farmers are also seed-rationed, because of cash constraints.

These cash constraints are not effectively relieved through credit as it is currently

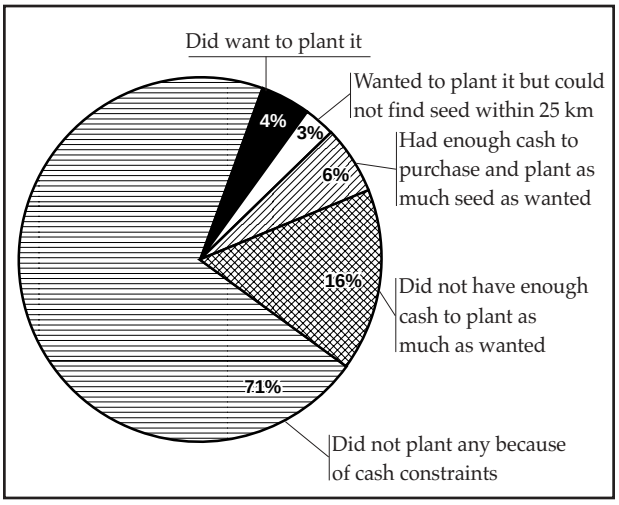

Figure 5. Farmers' demand for F_1 hybrid maize seed in Malawi, Malawi, 1996-97.
Source: CIMMYT/MoALD survey data.

[16] This finding is consistent with results of the 1993 Farmer Evaluation Survey. At that time, 96% of the farmers (a subset of about 150 out of the original 420 who participated) stated that if they had a hard and weevil-resistant maize type they would be willing to buy it, and 98% said MH18 was weevil resistant. In the 1996-97 survey, among the 349 farmers who remained in the sample, the preferred maize hybrid was MH18, followed by NSCM41 and MH17.

[17] These farmers explained that seed could not be found for at least 25 km and that traders were not selling seed locally. Ng'ong'ola, Kachule, and Kabambe (1997) also reported that few farmers complained about distance from the purchase point for fertilizer, implying that purchasing power is more of a problem than physical access.

provided. Those who stated that they did not have enough cash to buy any or as much F_1 hybrid seed as they wanted were then asked whether they sought credit for seed from any source. The distribution of these responses is shown in Figure 6, along with their classification according to the conceptual framework we described previously.

In 1990, 27% of survey farmers were members of credit clubs administered by SACA. In 1997, only 10% of the survey farmers used credit for *any* agricultural purpose. Only 3% of farmers whose demand for F_1 seed was constrained by cash were able to obtain credit to buy seed. The largest proportion of the remaining households were nonborrowers; in other words, they do not want to use credit because the interest rates are too high (for any crop), or they were afraid of the consequences of indebtedness. Some of these had unfavorable experiences with credit repayment with either SACA or MRFC. Others based their opinion on what they had observed or what they believed based on their own information. Blantyre farmers appear more likely to be nonborrowers than Kasungu or Mzuzu farmers (Appendix Table C4).

The next largest group consisted of rejected borrowers – farmers who stated they had sought credit and had been rejected because of their own personal borrowing history, the history of the group of borrowers to which they belonged, the history of groups in the village (for which they too were penalized), their age and status, or reasons unknown to them. The group of rejected borrowers is much higher in Kasungu and Mzuzu than in Blantyre, which can be explained by the greater past participation in the SACA credit program (and probably, the default history) in those zones (see also Appendix Table C4).

About one in five farmers whose demand for F_1 seed was cash-constrained were rationed borrowers. Since they did not have enough cash to purchase the amount of F_1 seed they wanted, they sought credit but were unable to obtain it, because (1) credit was unavailable in their village, (2) credit was limited to few individuals (in the case of NGOs, in particular, since these terms were highly favorable), or (3) credit was available for tobacco but not for maize seed. This group includes farmers who obtained credit for purposes other than the purchase of F_1 seed — principally tobacco but also packages of soybeans and improved OPV seed (from the NGO Lutheran Evangelical), or personal loans for fertilizer. The proportion of survey farmers who were credit-rationed was much higher in Blantyre and Mzuzu than in Kasungu.

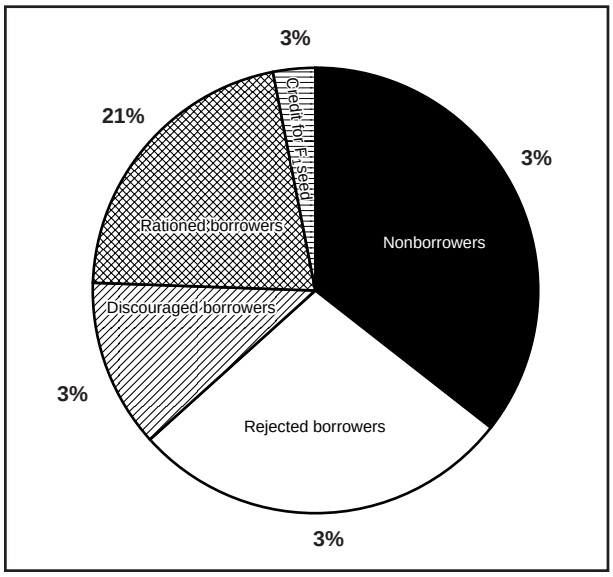

Figure 6. Farmers whose demand for F_1 hybrid maize seed was cash-constrained in 1996-97. (Farmers who planted no F_1 seed or planted less seed than they wanted to plant.)
Source: CIMMYT/MoALD survey data.
Note: **Rationed** = credit unavailable, limited to few members, or obtained credit but not for F_1 hybrid maize seed. **Discouraged** = knew would not qualify; did not apply. **Rejected** = rejected because of default history of farmer or other farmers; or rejected for unknown reason. **Nonborrower** = did not want credit.

The final subgroup shown in Figure 6 is the discouraged borrowers, who did not seek credit because they did not believe they would qualify. In interpreting responses, it is important to recognize that the change in credit regimes during recent years often made it difficult to distinguish between a rejected borrower, a nonborrower, and a discouraged borrower. First, farmers' responses are based on their information and knowledge. Not all farmers know about current credit opportunities or the difference between the terms offered by SACA and MRFC. Second, under SACA, farmers "qualified" according to a number of socioeconomic indicators, but the terms of loan repayment were far easier at that time than they are today. With MRFC, interest rates in 1996-97 were 36% per season, but farmers could "qualify" if they were able to pay a 10% deposit and had no default history. Since many of the survey farmers had defaulted on past loans or could not pay the 10% deposit, some of them may not have considered applying for a loan. These farmers are distinct from other farmers who are classified as "discouraged borrowers," such as recently widowed women who feel they are "powerless" and "can't manage a loan." The nonborrower group may also include defaulters who would be rejected but reported to us that they did not want credit.[18]

Comprehensive analyses of credit use have been undertaken in Malawi by the International Food Policy Research Institute (IFPRI) and Bunda College of Agriculture. Based on this research, Diagne, Zeller, and Mataya (1996) found that a majority of households were credit-constrained. They also found that credit use was associated with greater investment in hybrid seed and fertilizer, as well as tobacco production — even when such credit was obtained for nonagricultural uses. Despite that fact, over two-thirds of the agricultural input expenditure of credit program participants was self-financed. Ng'ong'ola et al (1997) have also reported that a large proportion of smallholder farmers had problems acquiring credit in 1995-96 to purchase modern inputs. Like the enumerators in the CIMMYT/MoALD survey, they noted that with the collapse of SACA some farmers did not know where to apply for credit.

Relationship of Source of Cash and Household Head to Use of Hybrid Seed

If credit on attractive terms is not available for the use of seed and fertilizer in maize production, where do farmers obtain the cash to purchase these inputs? The relationship of some simple indicators of cash sources to use of F_1 hybrid seed and application of fertilizer to maize is shown in Table 8.[19]

Tobacco is the "green gold" of smallholder production. It is hoped that smallholders' participation in the export market for burley tobacco can generate enough cash in rural areas to raise household incomes significantly and create a multiplier effect through the demand for labor, goods, and services. It is also hoped that burley tobacco, fertilizer, and hybrid maize can create a "virtuous circle" to replace the vicious circle of low productivity and increasing poverty (Orr, forthcoming B).

Certainly the tobacco-growers in our sample were significantly more likely to have grown F_1 hybrid maize in 1997 than those who did not grow tobacco. In 1990, only 12% of survey

[18] In general, discussions about credit were somewhat sensitive.

[19] In the 1996-97 survey, largely because of logistical and time constraints, we could obtain only crude indicators of cash sources.

farmers grew tobacco, and those farmers were found almost exclusively in the Kasungu survey zone. They also grew primarily dark-fired tobacco, with some oriental tobacco. In 1997, with the market for burley tobacco open to smallholders, 47% of all survey farmers, and the majority of farmers in Kasungu, grew tobacco.

Measurement problems make it difficult to capture the effects of off-farm employment on use of F_1 seed. A significant difference was found among the Mzuzu farmers between those whom we classified as having "regular" cash income and other farmers. Here, we have classified wage employment, operating a grocery, and semiskilled labor (such as tailoring, carpentry, building, or baking) as a source of regular cash. Other sources of cash that farmers called "regular" included brewing beer, producing charcoal or selling firewood, hawking, or working on other farms (*ganyu*) or on estates. Among the Mzuzu farmers, growing cash crops other than tobacco (including soybeans, groundnuts, and vegetables) was also significantly associated with the likelihood of growing F_1 hybrid maize. There is such a wide range of value to cash crops (groundnuts to bananas, sugarcane to okra), however, that this relationship was in general not well defined.

Table 9 provides evidence that although the sex of the household head is not related to the use of F_1 seed, households headed by men are more likely to use fertilizer on maize than households headed by women. In 1990, 24% of the survey households were headed by women; in 1997, 30% were headed by women, with the largest increase in Mzuzu. This result undoubtedly reflects the differences in cash-earning opportunities between men and women.

Table 9. Relationship of hybrid seed and fertilizer use to sex of household head, Malawi, 1997

	Percentage farmers growing hybrid maize	Percentage farmers using fertilizer on maize
Female-headed	21	9 *
Male-headed	24	35

Source: CIMMYT/MoALD survey data.
Note: * indicates statistically significant difference between subgroups (5%) with Chi-squared test.

Table 8. Relationship of hybrid seed and fertilizer use to sources of cash, Malawi, 1997

	Percentage of farmers growing hybrid maize	Percentage of farmers using using fertilizer on maize
Growing tobacco	29 *	54 *
Not growing tobacco	10	27
With regular nonfarm source of cash[a]	34	57
Without regular nonfarm source of cash	20	49
Growing other cash crops[b]	22	52
Not growing other cash crops	22	43

Source: CIMMYT/MoALD survey data.
Note: * indicates statistically significant difference between subgroups (5%) with Chi-squared test.
[a] Difference is statistically significant only in Mzuzu survey zone for use of F_1 hybrids.
[b] Difference is statistically significant only in Mzuzu survey zone for use of fertilizer.

Farmers' Perceptions of Their Own Welfare

To elicit farmers' perceptions of changes in their own welfare from 1990 to 1997, we asked them to begin by listing the features of a well-to-do household in their community. They then compared the change in their own status over 1990-97 in terms of the features they cited. The most frequently cited features of well-to-do farm households, and farmers' opinions about whether they themselves are today better off, the same, or worse off, are summarized in Table 10.

Producing enough maize to last from harvest to harvest, rather than profitability, remains the driving objective among survey households (see also Peters, 1996). Almost 90% of households stated that a defining characteristic of a well-to-do household is its ability to meet maize consumption requirements, while others identified possession of livestock, a house with an iron roof and bricked walls, an oxcart or other farm machinery, and possessing several changes of clothing as defining characteristics.

The majority of Malawi's smallholders cannot meet the criterion of self-sufficiency in maize production, and for many the goal of food security is elusive, because cash-generating opportunities are so limited. Most of these farmers have modest expectations but have great difficulty meeting them. Expectations are higher in the tobacco-growing and estate areas and among younger farmers. For these farmers, a "well-to-do" household has enough maize to sell, a diet with meat, oil, and different types of relish for porridge (*nsima*), laborers, a motor car, or cash savings. Farmers in Mzuzu mentioned the importance of more diversified crops for sale or consumption, and farmers in both Mzuzu and Blantyre frequently reported that owning a small business or small grocery was a feature of well-to-do households. Farmers in Kasungu were more likely to mention farm machinery and cash savings.

Table 10. Malawian farmers' perceptions of welfare changes from 1990 to 1997

	Agricultural Development Division			
	Blantyre	**Kasungu**	**Mzuzu**	**All**
	percent farmers			
Most frequently cited features of well-to-do farm households				
Maize stocks last from harvest to harvest	79	90	89	86
Owns cattle, sheep, goats, pigs, or chickens	78	82	92	82
Lives in house with iron roof and/or brick walls	53	67	45	58
Owns an oxcart or other farm machinery	11	49	4	27
Owns several changes of clothing	22	18	22	20
Welfare status of farm household				
Better off in 1997	37	30	26	32
The same in 1990 as in 1997	19	26	31	24
Worse off in 1997 than in 1990	44	44	43	44

Source: CIMMYT/MoALD survey data.

Among farmers in Kasungu, growing burley tobacco in 1996-97 was significantly associated with perceived changes in welfare. About 80% of the farmers who reported they were worse off today than in 1990 did not grow burley, compared to 40% of those who did. Growing burley tobacco tripled the percentage of farmers who reported they were better off or the same as in 1990. Tobacco cannot serve as a panacea for rural poverty in Malawi, however. The market cannot expand indefinitely, tobacco production can only absorb so much rural labor, and many smallholders farm soils that are unsuitable for the crop.

Prospects and Discussion

The findings of the 1996-97 CIMMYT/MoALD survey demonstrate convincingly that since the release of such varieties as the semiflint hybrids MH18 and MH17 (nationally bred) and the dent, but early maturing, hybrid NSCM41 (licensed from Ciba-Geigy), smallholders' use of F_1 hybrid seed in Malawi is no longer constrained by the grain quality or yield characteristics of maize hybrids. Survey farmers, all of whom have now had experience growing hybrid maize, stated almost unanimously that they wanted to grow F_1 hybrid seed this cropping season. The majority of these farmers, however, were constrained by liquidity problems; they could not generate the cash or obtain the credit to purchase as much as they wanted to plant. In 1996-97, one in five of the survey farmers grew some F_1 hybrid seed and 47% applied some fertilizer. From 1990 to 1997, however, only a scant 7% of farmers were able to grow F_1 hybrid seed year after year.

These data are consistent, however, with Ng'ong'ola's statement that, "Partly as a result of releasing these [semiflint] varieties, hybrid maize has substituted for local maize in production since 1990-91"(1996:32). If adoption refers to the stated preferences of individual farmers, their acceptance of a seed type, or their use of F_1 as well as advanced-generation hybrids, then adoption of maize hybrids among these smallholders is fairly high. More than 20% have used F_1 hybrids in each year since 1990; from 1993, between about 40% and 60% have used advanced-generation hybrids in any given year; and almost all farmers in the sample who have used the maize hybrids currently available in Malawi stated that they liked the germplasm. These adoption percentages would be lower, of course, for the nation as a whole, since the zones included here are among the major maize-growing zones in Malawi.

Although "adoption" may be relatively high when viewed from this perspective, "research impact" is extremely low. The "impact" of research is determined by the combined effect of technology, infrastructure, and policy factors, as well as the yield advantage of the improved material, which declines with recycling. At the current seed-to-grain price ratio for hybrids, given the low base levels of farmers' yields and the early stages of their knowledge about maize hybrids, the profitability of F_1 hybrid seed is probably borderline for most small-scale farmers. Maize prices below export parity levels, spiraling inflation, and successive devaluations further depress demand and make it difficult to estimate long-run input and output prices. The deepening poverty of segments of the rural population, documented in the sources reported in the text and reflected here in farmers' responses,

may be the foremost cause of the contracting demand for purchased inputs in maize production. There is evidence that "liberalization" has not extended to all inputs. Given the current structure of the seed industry and its legislative framework, even the important policy changes that have occurred may not be sufficient to reduce the transactions costs farmers face in obtaining seed. Road infrastructure remains a key factor, and the condition of roads is declining in many areas of the countryside. Although the government of Malawi and NGOs are exploring the prospects for farmers to multiply seed of improved OPVs and top-cross hybrids, no small or medium-sized seed companies seem as yet to have had an economic incentive to form.

Like "adoption," "impact" is difficult to gauge, however. Instead of thinking in terms of the absence of maize yield increases, we can picture what the maize yield trend would have looked like if no improved seed had been released; rather than cite the decline in sales to smallholders, we can question the diffusion curve itself. The survey data confirm that recycling and discontinuities in use of F_1 seed underlie the shape and "fuzziness" of the cumulative diffusion path depicted in Figure 1. If we assume, for example, that the difference between the seed sales and national crop estimates is primarily the result of recycling, the ratio of percentage area in F_1 hybrids to percentage area in advanced-generation hybrids is of the same order in the survey data as it is in the national data (roughly 1 to 3). A methodological issue is raised by this finding: if recycling of hybrid seed is an increasingly common practice, which, in fact, is the diffusion curve for the germplasm?

Most of the recycled hybrid seed is seed of semiflint hybrids. Is recycling of top-cross semiflint hybrids necessarily "bad"? Farmers recognized yield declines over time, but reported that poundability did not usually worsen. Experimental results suggest that F_2 top-crosses and three-way crosses still yield more than local maize. There is anecdotal evidence from the previous research and the 1996-97 survey that farmers may in some sense classify MH18 as "local" maize — at least with respect to some of its attributes. Given the early phase of the diffusion path for hybrid maize in Malawi, the start-stop nature of policies affecting the use of inputs in maize production, and free issues of seed by the government and NGOs, the large percentages of farmers recycling hybrid seed is not surprising

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Such practices may also be more common than is discussed in the adoption literature. One policy implication of this study is that it may be worthwhile for the Malawian national program and CIMMYT to investigate prospects for producing hybrids whose characteristics resist deterioration from recycling. Such a hybrid would be a variety cross, or a line by variety cross, or a single-cross hybrid top-crossed to a variety. In general, the more heterozygous the parent, the more variable the hybrid product, but the slower the deterioration of the product as the seed is saved and grown again from year to year (G. Edmeades, pers. comm.).

The pressing concern of national maize production and food security still must be addressed. In Malawi, maize remains the food staple. Who will produce the surplus maize needed to feed the farmers who cannot meet their consumption requirements, the rural landless, and the urban population? In the past, the surplus maize producers in this sample of farmers were

found in Mzuzu and parts of Kasungu. The changes between the two survey periods are most striking in the Mzuzu survey area:

- The percentage of farmers growing F_1 hybrid seed dropped from 40% to 18%, while the percentage of farmers growing local maize declined much less than in the other zones.
- The percentage of all maize area in the survey zone fell from 22% to 6%.
- The percentage of farmers continuously growing F_1 hybrid seed is half that found among Kasungu farmers.
- The percentage of farmers fertilizing their F_1 hybrid seed fell from 97% to 60%.
- The percentage of farmers receiving F_1 hybrid seed as a gift (held over from the previous year or obtained from friends or relatives) was higher than in other survey zones.
- Regular, nonfarm sources of cash and growing other cash crops (excluding tobacco) were associated with use of F_1 seed in that region but not in the others.

Clearly, under this pricing and credit regime, the Mzuzu farmers in the sample (Central Mzimba, primarily) are no longer able to produce a marketable surplus. Nor is it necessarily profitable for traders to operate in that zone. Although Blantyre farmers are using F_1 hybrid seed, they farm such small areas that even with hybrid maize they probably will remain deficit producers. Of the three zones in the survey, the most likely to produce a maize surplus would be Kasungu. Increasingly, these households may choose to allocate more land to tobacco, although tobacco is labor- rather than land-intensive. Finally, farm size differentiation has implications for the production of maize surpluses. Farmers who have the resources to use credit, purchase inputs, grow cash crops, or produce maize surpluses represent a smaller and smaller percentage of farmers — as implied by various estimates of the farm size distribution among smallholders.

As a sample survey with modest objectives, this survey has enabled us to raise more issues than we can answer. By monitoring input use over time, especially in political and economic environments that change as rapidly as some of those in sub-Saharan Africa, we may gain a better understanding of the economic processes that will be involved in attempting to raise yields. Biological yield increases, as compared to expansion of cropped area, are the key to future increases in maize output in Malawi and in the developing world in general. Seed and fertilizer technology is not sufficient in itself, however, to resolve the problem of stagnating maize productivity in Malawi.

In a recent document (World Bank Group 1996:7), the World Bank stated that the "objectives of poverty reduction, sustainable natural resources management and food security cannot be met unless rural well-being in general, and a *prosperous smallholder agriculture in particular,* are nurtured and improved" (our italics). "Family farmers and nonfarm enterprises in rural areas should provide adequate employment opportunities, and should be linked to well-functioning markets for products, inputs, and finance" (p. 11). The same document acknowledges that in sub-Saharan Africa, however, the World Bank will not continue to finance agricultural marketing, input supply, processing, or rural credit through the public sector. In a country that relies on agriculture as much as Malawi, but where infrastructure is inadequate, nonfarm employment opportunities are few, and incentives are insufficient to mobilize trade and cash generation in rural areas, can complete reliance on private initiatives succeed?

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Appendix A
Second CIMMYT/MoALD Survey of Maize Variety Adoption, 1997

IDENTIFICATION

Farmer name _____ ADD code _____[1] EA code _____[2]HH number_____[3]

Grew hybrid seed before (MS) 1989-90 ____[4] 1990-91____[5] 1991-92____[6] (yes=1 no=2)

Change of household head since 1990-91? _____[7] (yes=1 no=2)

Current age of household head _____[8] Current sex of household head _____[9](male=1; female=2)

Current household size (as defined by ASA rules)_____[10]

Enumerator comments: _____[11]

Use of varieties and fertilizer since last survey

1. In each season since 1990-91, what maize varieties did you grow? Did you apply fertilizer to each variety?

1991-92		1992-93		1993-94	
Variety	Fertilizer 1=yes; 2=no	Variety	Fertilizer 1=yes; 2=no	Variety	Fertilizer 1=yes; 2=no
[12]-[18]	[19]-[25]	[26]-[32]	[33]-[39]	[40]-[46]	[47]-[53]

1994-95		1995-96		1996-97	
Variety	Fertilizer 1=yes; 2=no	Variety	Fertilizer 1=yes; 2=no	Variety	Fertilizer 1=yes; 2=no
[54]-[60]	[61]-[67]	[68]-[74]	[75]-[81]	[82]-[88]	[89]-[95]

Enumerators: just combine all local maize varieties under "local," but try to obtain variety names for hybrids and composites.

2. Quantity of seed planted in 1996-97, ALL varieties (including local). If purchased, prices and source of seed.

Variety	**Quantity of seed planted**	**How obtained? 1=own seed 2=cash purchase 3=credit (any source) 4=*ganyu* 5=gift**	**If not own seed, where obtained? (e.g., describe store or program)**	**If purchased, price per unit**
[96]-[102]	[103-109]	[110-116]	[117]-[123]	[124]-[130]

Enumerator: just repeat the names of all of the varieties from (1), 1996-97 in the variety column. Report the price in terms of a quantity. If the farmer paid in kind or ganyu *write out the conditions of exchange. Examples of sources of seed: (a) another farmer (b) ADMARC (c) Chipiku (d) another type of local store (e) traveling trader (f) government or NGO program—give name.*

3. Was the seed obtained this year from a store, trader, etc. in a registered bag? Or was it grown in previous years and the seed saved by the farmer (if so, for how many years?)

Enumerator: This question is about recycling of seed for hybrid maize varieties. Repeat the names of the hybrid maize varieties grown in 1996-97.

Variety of hybrid maize	**New this year or saved from previous harvests?**	**If saved, for how many years?**
[131]-[137]	[138]-[144]	[145]-[151]

General information

1. Describe a well-off farm household (three of four aspects).

   a. _____[152]
   b. _____[153]
   c. _____[154]
   d. _____[155]

2. What is the difference between your household and the well-off household (for each aspect in [1])?

   a. _____[156]
   b. _____[157]
   c. _____[158]
   d. _____[159]

3. Are you closer to being like the well-off household today than you were the last time we saw you in 1991?

   closer as close as we were then farther [160] (circle one)

4. This season, did you grow tobacco? _____[161] (yes=1 no=2)
   If yes, specify type _____ [162]

5. This season, did you grow crops other than tobacco or maize? ___[163] (yes=1 no=2)

   If yes, specify _____[164] _____[165]
   _____[166] _____[167]

6. Did you apply fertilizer to any of your crops other than maize? ___[168](yes=1 no=2)

   which_____[169]
   _____[170]

7. Of all crops including maize, which covered most of your land this year? _____[171]

8. This year, do you have any regular source of cash working off of your farm?
   _____[172] (yes=1 no=2) Comments: _____

Appendix B
Major Characteristics of Survey Zones

The three survey zones have distinct agroecological and socioeconomic characteristics, [20] although there is variation within zones and some clusters are also similar between survey zones. Farmers in the Blantyre zone cultivate smaller areas in a wider range of microclimates and soil conditions. There is a longer history of estate agriculture in Blantyre, and farmers rely less on credit in farm production and more on off-farm income for their livelihood. Household heads are more likely to be women and less likely to be formally educated. They are less likely to have livestock, but they often have sources of regular cash, and the dense population means that trading centers and roads lace the rural areas (even though these may be in poor condition). While these farmers plant most of their land to maize, they are and have long been deficit maize producers.

Farmers in the Kasungu zone cultivate the more fertile soils of the Central Plains, under a more homogeneous temperature and rainfall regime. Most grow maize, groundnuts, and the high-valued export crop, tobacco. Their average farm size is over one hectare. They were in the past and are still more likely than the other survey farmers to use farm credit. Some of these farmers now plant more land to tobacco than to maize, although maize generally dominates crop area.

Farmers in the Mzuzu zone are primarily located in the sparsely populated areas of Mzimba District, where road infrastructure and trading opportunities are less extensive. Although the agroclimate is broadly similar to that of Kasungu, the soils may be less fertile — farmers generally prefer to apply higher levels of fertilizer. Farm sizes are larger in Mzuzu, and more farmers use oxen, ridgers, and oxcarts. These farmers rely on farming for their income, although male family members frequently migrate elsewhere (including South Africa or Zimbabwe). They grow a range of lower-valued crops other than maize (millet, cassava, groundnuts, sweet potato), but they did not grow tobacco until recently when that market was liberalized. In the initial CIMMYT/MoALD survey, these farmers were more likely to grow hybrid maize because for them maize was a cash crop as well as a subsistence crop.

[20] This Appendix is based on data reported in Smale et al. (1991).

Appendix C
Descriptive Tables on Farmers' Input Use, Maize Area, and Demand for Hybrid Seed, Malawi, 1990s

Appendix Table C1. Percentage of farmers growing local, composite, and hybrid maize seed, Malawi, 1990-97

Year and maize type	Agricultural Development Division			
	Blantyre	Kasungu	Mzuzu	All
1990				
F_1 hybrid maize	14	33	38	27
Advanced-generation hybrid maize	4	7	9	6
Composite maize	4	4	5	4
Local maize	97	99	97	98
1991				
F_1 hybrid maize	30	39	40	36
Advanced-generation hybrid maize	7	22	10	14
Composite maize	2	1	1	1
Local maize	98	96	99	97
1992[a]				
F_1 hybrid maize	98	95	96	96
Advanced-generation hybrid maize	0	1	0	0
Composite maize	0	0	0	0
Local maize	66	69	95	73
1993				
F_1 hybrid maize	14	33	21	24
Advanced-generation hybrid maize	71	53	69	63
Composite maize	1	1	1	1
Local maize	68	68	89	72
1994				
F_1 hybrid maize	19	29	16	23
Advanced-generation hybrid maize	51	42	49	47
Composite maize	0	1	0	0
Local maize	72	63	82	70
1995				
F_1 hybrid maize	19	50	23	34
Advanced-generation hybrid maize	45	34	36	38
Composite maize	0	1	0	0
Local maize	72	57	88	68
1996				
F_1 hybrid maize	37	45	30	39
Advanced-generation hybrid maize	31	41	37	37
Composite maize	3	0	0	1
Local maize	71	57	86	67
1997				
F_1 hybrid maize	14	30	18	22
Advanced-generation hybrid maize	44	62	53	54
Composite maize	4	0	0	2
Local maize	76	57	85	69

Source: CIMMYT/MoALD survey data.

Note: "Year" refers to year harvested. "All" category is weighted by probability of selection. Advanced-generation hybrids include mixtures of local and recycled hybrid maize.

[a] In this season, all survey farmers were given 5 kg of hybrid maize seed to evaluate (see Smale et al. 1993).

Appendix Table C2. Maize area by maize type, Malawi, 1990, 1991, and 1997

Year and maize type	Agricultural Development Division			
	Blantyre	Kasungu	Mzuzu	All
	—mean ha planted for farmers growing maize type—			
1990				
Local maize	0.72*	0.97*	1.01	0.88*
F_1 hybrid maize	0.25	0.49	0.72*	0.44
Advanced-generation hybrid maize	0.22*	0.36*	0.23*	0.28*
Composite maize	0.42	0.33	0.00	0.30
1991				
Local maize	0.77	0.85	1.12	0.87
F_1 hybrid maize	0.34	0.72	0.66	0.57
Advanced-generation hybrid maize	0.33	0.49	0.29	0.39
Composite maize	0.33	0.76	0.45	0.54
1997				
Local maize	0.67*	0.78*	0.97	0.77*
F_1 hybrid maize	0.37	0.49	0.44*	0.44
Advanced-generation hybrid maize	0.35*	0.68*	0.48*	0.52*
Composite maize	0.30	0.00	0.00	0.11

Source: CIMMYT/MoALD survey data.

Note: "Year" refers to year harvested. "All" category is weighted by probability of selection. Advanced generation hybrids include mixtures of local and recycled hybrid maize. An asterisk (*) indicates that the difference between years is statistically significant, by maize type and stratum, one-tailed t-test (5%).

Appendix Table C3. Percentage of farmers applying fertilizer, by maize type, Malawi, 1990-97

Year and maize type	Agricultural Development Division			
	Blantyre	Kasungu	Mzuzu	All
1990				
F_1 hybrid maize	71	97	97	87
Advanced-generation hybrid maize[a]	–	–	–	71
Local maize	44	52	53	50
1991				
F_1 hybrid maize	93	96	100	96
Advanced-generation hybrid maize[a]	–	–	–	59
Local maize	57	59	52	57
1992				
F_1 hybrid maize	44	62	60	55
Advanced-generation hybrid maize[b]	–	–	–	–
Local maize	36	36	42	37
1993				
F_1 hybrid maize	35	29	38	33
Advanced-generation hybrid maize	36	51	48	45
Local maize	30	40	49	38
1994				
F_1 hybrid maize	68	87	78	78
Advanced-generation hybrid maize	37	36	44	38
Local maize	32	42	43	38
1995				
F_1 hybrid maize	77	76	69	75
Advanced-generation hybrid maize	36	54	59	48
Local maize	29	52	46	42
1996				
F_1 hybrid maize	84	90	64	83
Advanced-generation hybrid maize	35	41	59	42
Local maize	37	48	46	44
1997				
F_1 hybrid maize	71	81	60	73
Advanced-generation hybrid maize	42	43	55	45
Local maize	28	43	51	39

Source: CIMMYT/MoALD survey data.

Notes: "Year" refers to year harvested. "All" category is weighted by probability of selection. Advanced generation hybrids include mixtures of local and recycled hybrid maize. "Applying fertilizer" means that at least some fertilizer was applied.

[a] Subsample sizes too small to report figures by Agricultural Development Division.

[b] In 1992, no advanced-generation hybrids were grown.

Appendix Table C4. Demand for hybrid maize seed and constraints to its use by farmers, Malawi, 1996-97

	Agricultural Development Division			
	Blantyre	Kasungu	Mzuzu	All
	percent farmers			
Farmers who wanted to plant F_1 hybrid seed this season	97	95	91	95
Of these, farmers stating seed was locally available	99	100	87	97
Of these, farmers with enough cash to purchase as much F_1 seed as they wanted	5	9	4	7
Of farmers who did not have enough cash to purchase as much F_1 seed as they wanted:				
Those who did not want credit	47	27	32	35
Those who asked for credit but were rejected	16	38	30	28
Those who knew they would not qualify	7	18	10	12
Those who said no credit was available	22	3	20	13
Those who obtained credit, but not for F_1 hybrid seed	8	9	6	8
Those who obtained credit, including for F_1 hybrid seed	0	5	2	3

Source: CIMMYT/MoALD survey data.

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