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Maize Research in Africa (MARIA) Project Case Study

Maize Is Life

Maize Research and Smallholder Production in Malawi

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Glossary of Acronyms and Abbreviations

ADD	Agricultural Development Division
ADMARC	Agricultural Development and Marketing Corporation
AES	Agroeconomic Survey
ARTS	Adaptive Research Teams
ASA	Annual Survey of Agricultural
CARO	Chief Agricultural Research Officer
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
DAR	Department of Agricultural Research
DAP	Diammonium phosphate
EA	Enumeration Area
FAO	Food and Agriculture Organization
FSNM	Food Security and Nutritional Monitoring
FSR	Farming Systems Research
GDP	Gross Domestic Product
GOM	Government of Malawi
HYV	High-Yielding Variety
IITA	International Institute for Tropical Agriculture
LLDP	Lilongwe Land Development Programme
MADIA	Managing Agricultural Development in Africa (World Bank)
MK	Malawi kwacha—US$1 = 4.23 kwacha (as of mid 1993)
MOA	Ministry of Agriculture
MVTS	Maize Variety and Technology Adoption Survey
NSCM	National Seed Company of Malawi
NSSA	National Sample Survey of Agriculture
OPV	Open-Pollinated Variety
RDP	Rural Development Projects
SAL I-III	Structural Adjustment Loans I - III
USDA	United States Department of Agriculture

Glossary of Definitions

Composites: Improved open-pollinated varieties developed from the genetic combination of a wider range of parental material than is usually the case for synthetics.

Hybrids: Improved maize for which pollination is carefully controlled at all stages of the seed production process. For most conventional hybrids, parental material consists of inbred lines for which plants are self-pollinated over several generations. The controlled crosses of two, three, or four of these inbred lines lead to conventional hybrid seed. Where plants are allowed to randomly pollinate, genetically-caused deterioration in the yield of hybrid maize is high implying that, for farmers who have begun using hybrid seed, it is usually economically rational to purchase new seed every year.

OPVs (Open-pollinated varieties): Maize varieties in which seed production is the result of random pollination of silking plants by pollen from the tassels of other plants. These can include farmers' varieties as well as improved varieties developed through synthetic or composite breeding strategies. Genetically-caused deterioration in the yield of OPVs occurs relatively slowly over time implying that, for farmers who have begun using seed of improved OPVs, it is usually economically rational for them to use their own grain as seed for several generations before replacing it with higher quality purchased seed.

Synthetics: Improved open-pollinated varieties developed from a breeding and seed-production procedure similar to the one used to produce hybrid maize, but for which actual seed production takes place under open-pollinated conditions. Resulting varieties have a relatively narrow genetic base.

1. Introduction

Maize replaced millets and sorghum as the dominant foodgrain crop in Malawi only 60 to 70 years ago, but over three-quarters of the nation's cultivated area is now sown to maize each cropping season. Per caput, the quantity of maize Malawians consume as a starchy staple is perhaps the greatest in the world. "Maize is our life (*chimanga ndi moyo*)," and the ideal of producing sufficient maize for the maize porridge (*nsima*) needs of the household "informs everyone's actions and rationales for their actions before, during, and after the maize harvest."[1] Each "hungry season" when their maize stocks have been depleted, many farm households face undernutrition as maize prices rise prohibitively and supplies at local market outlets fluctuate. Food preferences and the risks associated with relying on product markets imply that, in Malawi, farm household decision-making is motivated by the objective of producing enough maize to satisfy annual subsistence needs.

As staple food requirements to sustain a growing population increase, diffusion of suitable higher-yielding varieties has become a food security imperative.[2] In the short-term, land-saving technological change can only be achieved in Malawi through adoption of seed-fertilizer technology. Soil fertility maintenance by traditional methods such as fallowing and rotation has become increasingly difficult as farmers expand their maize area and monocrop in an attempt to secure family grain requirements in the face of chronically low maize yields. Releasing land for the cultivation of other food crops that are essential to improving nutritional standards and for production of export crops that earn valuable foreign exchange cannot be accomplished without improving maize yields.[3]

Malawi has a labor-land ratio that is high by African standards (Binswanger and Pingali, 1988) and agroclimatic conditions that are favorable for a seed-fertilizer transformation. Malawi's maize research program has released hybrids, synthetics, and composites for over 30 years but, until the late 1980s, no more than about 10 percent of aggregate maize area was sown to hybrids or first-year open-pollinated varieties. Recent data (CIMMYT/MOA; FSNM) demonstrate that, especially in higher-potential, maize-producing zones, the percentage of farmers sowing hybrid maize has grown rapidly in the past four seasons. Aggregate area in hybrids has remained fairly low because, even when farmers have adopted hybrid maize, they continue to devote a large proportion of their household's maize area to local varieties.

Certain consumption preferences of Malawian farmers, among other features of input supply and distribution, have been frequently

[1]From villagers' statements, cited in Peters, 1988.

[2]In post-World War II Nyasaland, Kettlewell already expressed concern over declining productivity as increasing population pressure on the land tended towards maize monocropping. Even before independence he described parts of the Southern Region of Malawi as having high population densities and large numbers of farm households with less than a hectare of land (Kettlewell, 1965).

[3]Similarly, Kettlewell wrote that conditions in Malawi demonstrated the vulnerability of a food supply so dependent on a single crop, and the importance of reducing the proportion of land under maize to facilitate crop rotation and production of other crops. At that time as now, "the first part of the problem of agricultural progress was to raise the yield of maize per unit area throughout the country" (p. 258).

cited as factors limiting the popularity of hybrid varieties. Malawians reveal a distinct consumption preference for the flinty varieties loosely categorized as "local," or "maize of the ancestors (*chimanga cha makolo*)." These varieties are more efficiently processed into the fine white flour (*ufa woyera*) used to prepare the preferred type of porridge, and their hard grain is more resistant to weevil attack in storage than most of the denty, white hybrids that have been introduced in the past. For this reason, hybrid maize was until recently promoted as a cash crop, although some substitution of hybrid maize for local varieties in consumption is increasingly perceptible and is unavoidable for the food-deficit households who represent the majority in Malawi. In recognition of the importance of consumer preferences in smallholder adoption decisions, the Department of Agricultural Research (DAR) has periodically released semiflint OPVs. For the 1991–92 season, DAR also released two new semiflint hybrids and promotional efforts are emphasizing improved processing and storability traits. Evidence suggests that the new semiflint hybrids perform well relative to both denty hybrids and local maize in terms of yield, processing, and storage characteristics (Smale et al., 1993; Jones and Heisey).

As a case study, the history of maize research in Malawi is of policy interest for two principal reasons. First, although various factors suggest that the agroeconomic setting is favorable for HYV adoption, farmer adoption rates have risen very slowly. Understanding adoption patterns in Malawi has implications for other maize-producing and -consuming zones. Second, although the significance of flint maize preferences in household decision-making has long been recognized by the breeding program, a perceptible tension appears to have existed historically between the recognition of grain quality as a trait and the importance of yield criteria. For farmers who grow improved varieties as a cash crop, processing and storage efficiency is of no significance and yield at harvest is critical. Maize-deficit farmers who want to consume their maize are concerned about yield from the mortar. Flintiness and yield criteria have also been related to the issue, spurred by donor involvement, of whether hybrids or OPVs should be emphasized.

Consumer preference for flinty maize may be a relevant issue for breeding programs in the broader region encompassing the maize-producing zones of Tanzania, Zambia, and perhaps Mozambique. In all of these zones, maize production by smallholders is a critical food security issue, and similar preferences are likely to affect adoption decisions.

Scope and Purpose of Case Study

The objectives of the Malawi case study are to (1) provide a profile of the more significant historical changes in farmers' varietal choice (research impact as expressed by adoption rates); (2) summarize associated changes in aggregate maize production figures and related welfare statistics and suggest how these figures might have evolved under different technical change scenarios; and (3) document major factors in research, extension, and promotion of these innovations that may have influenced the speed and breadth of technological change. The particular emphases of the Malawi case study are the rate of varietal change and the role of consumption preferences in both farmer decision-making and the breeding program.

Structure of the Report

The report begins by presenting evidence to illustrate the central importance of maize in the socioeconomy of Malawi.[4] The following section presents a time chart and outline of maize varietal releases and maize research activity. In

[4]Appendix B presents a review of secondary literature about aspects of the nation's approach to development policy that have affected smallholder maize production.

Section V, indicators of the effects of varietal adoption on farm families, major maize-producing zones, and selected macroeconomic variables are presented and interpreted. Section VI summarizes some of the major factors that have influenced the impact of maize research in Malawi, and the concluding section suggests some of the specific lessons that can be drawn from that experience.

2. Methodology

Both primary and secondary sources provide the information and data for the study. A review of secondary literature provides the background and context for maize research impact section (Appendix B). A combination of time-series data from the Annual Survey of Agriculture (ASA), recent findings from the Maize Variety and Technology Adoption Survey (MVTS), and selected figures from the Food Security and Nutrition Monitoring Survey Reports are used to generate the adoption rate statistics, characterize the impact of technical change on farm families and Agricultural Development Divisions, and identify some of the factors that have affected adoption rates (objective 1).[5] Secondary data are used to develop illustrative scenarios that express the effects of changes in maize seed technology on maize production, national food security, and agricultural GDP (objective 2). Interviews with key actors in the research system form the basis of observations relevant to objective 3.

[5]The major data sources are described in Appendix A. The data from the surveys are broadly representative of the major maize-producing zones of Malawi.

3. The Cultural and Economic Significance of Smallholder Maize Production

Among Malawians, *nsima* (stiff maize porridge) and food are synonymous.[6] Based on her interviews in Zomba, Peters reports that, for most households, to cultivate without cultivating maize was an "impossible thought." To have land is to grow maize, and growing maize is a way of life (1989, p. 48). The CIMMYT/MOA data from Mzuzu, Kasungu, and Blantyre Agricultural Development Divisions confirm that all survey households grew maize and, in 1989–90 and 1990–91 cropping seasons, devoted from 75 percent (Kasungu) to 98 percent (Blantyre) of their individual farm area to maize.[7]

The FAO *Food Balance Sheets* show almost a negligible change in maize as a percent of per caput daily caloric consumption from the late colonial period through the 1970s (Table 3.1). A net increase in total and maize calories is distinguishable over time. Although comparable figures have not been compiled for the 1980s, per caput utilization of maize as food in Malawi still ranked among the highest in the world (CIMMYT, 1990).[8]

In a nation in which agriculture constitutes an estimated 40 percent of GDP (Pryor, 1988), provides an estimated 45–50 percent of wage employment in the "modern sector" (Kydd and Christiansen, 1982; Pryor, 1988), and employs over 80 percent of the total labor force (Gulhati, 1989), maize is by far the dominant crop in terms of hectarage for all 8 Agricultural Development Divisions (ADDs) except Ngabu. Estimates of maize area as a percent of total cultivated area are shown in Table 3.2 for the 5 major maize-producing ADDs of Malawi, over time.[9] Differences among zones reflect alternative cash crop opportunities (tobacco and groundnuts, particularly in the Central Region), larger land areas to diversify food crops (millet, cassava, sweet potatoes, and beans, especially in the Northern Region), and subsistence requirements/land ratios (highest in the South). Considering sampling errors, differences over time are not evident over the brief period reported in the 1980s, but are likely to have emerged gradually between the late colonial period and present. At the national level, most estimates now predict that from 75 percent to 85 percent of total area cultivated by smallholders is sown to maize.

Finally, in an economy in which the value

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[6]Only in some zones around the lakeshore would cassava or rice be considered more important as a starchy staple.

[7]The *Report on an Economic Survey of Nyasaland 1958–59* reported that, on average, nearly 100 percent of an individual cultivator's land was sown to maize in the Southern Region, as compared with about 55 percent in the Central Region. As a point of comparison with today's estimates, Blantyre is located in the Southern Region, and Kasungu in the Central Region.

[8]Maize is believed to have gained its dominant position in the Malawian diet between 1850 and 1910 (Agroeconomic Survey, 1982). Williamson (1956) notes that although Lacerda (1790s) and Livingstone (1850s) refer to maize in their writings, both recount that the staple crops were millets, such as finger millet, and sorghum.

[9]Here, area is defined in terms of primary crop. In the NSSA and ASA, maize is only rarely recorded as a secondary intercrop. Counting the intercropped maize area in terms of the secondary crop would increase other crop area (especially for pulses and beans) as a percent of total cultivated area. The significance of intercropping may have declined over time, and appears greatest today in specific areas of high population density in the South, Dedza, and Ntcheu in Lilongwe ADD, and in Rumphi, Mzuzu ADD.

Table 3.1 Maize as Percent of Total Daily Caloric Consumption, Per Caput, 1961–1977

Year	---Per Caput Daily Calories--- Maize	Total	Maize Percent of Total
1961-65 (aver.)	1395	2092	67
1967	1379	2038	68
1968	1428	2149	66
1969	1500	2208	68
1970	1552	2313	67
1971	1530	2358	65
1972	1533	2336	66
1973	1520	2331	65
1974	1525	2331	66
1975	1417	2201	64
1976	1467	2265	65
1977	1448	2215	65

Source: Food and Agricultural Organization of the United Nations, Food Balance Sheets 1967-1977, Rome, 1980; International Maize and Wheat Improvement Center (CIMMYT) 1989/90 World Maize Facts and Trends, Mexico, D.F. 1990.

Table 3.2 Maize as Percent of Total Area Cultivated by Smallholders, 1958/59, 1968/69, 1980/81–1990/91

Year	-------------Agricultural Development Division*------------- Blantyre	Liwonde	Lilongwe	Kasungu	Mzuzu	All Malawi
1958/59						66–75
1968/69	88	89	81	70	77	
1980/81	89	88	76	67	75	
1985/86	91		83	76	73	
1986/87	89		80	66	69	
1987/88	93		82	66	76	
1988/89			82	67	77	
1989/90	96			82	83	
1990/91	98			70	81	75–85

*Figures for Mzuzu exclude Nkhata Bay, a cassava-producing zone, and for the last two years in Blantyre and Kasungu they exclude portions of the ADDS that are considered to be less representative with respect to maize production.

Source: Report on an Economic Survey of Nyasaland 1958-59, Federation of Rhodesia and Nyasaland, Ministry of Economic Affairs; National Sample Survey of Agriculture, 1968-69 and 1980-81, National Statistical Office, Government of Malawi; Annual Survey of Agriculture 1985-1989, Ministry of Agriculture, Government of Malawi; CIMMYT/MOA Maize Technology and Varietal Adoption Survey, 1989-91.

Table 3.3 Maize Value as Percent of Total Value of Smallholder and All Agricultural Output, 1970–1986
(million 1978 MK)

Year	Real Value of Output: Smallholder	Real Value of Output: Estate	Real Value of Output: Total	Real Value of Output: Maize	Maize % of Output Value: Smallholder	Maize % of Output Value: Estate
1970	150	41	191	59	40	31
1971	175	44	219	76	43	40
1972	184	50	234	80	43	34
1973	163	59	222	72	44	33
1974	169	59	228	81	48	36
1975	156	76	232	74	47	32
1976	186	84	269	74	40	27
1977	211	99	310	78	37	25
1978	217	102	319	84	39	26
1979	223	119	342	112	50	33
1980	202	130	332	82	40	25
1981	188	128	316	75	40	27
1982	189	151	340	121	64	36
1983	195	160	356	105	54	30
1984	210	151	352	104	50	30
1985	213			89	42	
1986	213			75	35	

Source: Smallholder and estate output estimates and GDP deflator from Pryor, F.L., Income Distribution and Economic Development in Malawi: Some Historical Statistics, World Bank Discussion Papers 36, Washington, D.C., 1988; Nominal maize producer prices from Gulhati, R., Malawi: Promising Reforms, Bad Luck, World Bank, Washington, D.C., 1989; Maize production figures from Food and Agricultural Organization of the U.N.

of estate production is considered to be the primary generator of foreign exchange earnings and national revenues, maize value as a percent of total value of smallholder and all agricultural output is high—especially for such a low-priced commodity. The estimates shown in Table 3.3 indicate that the percent of maize value in smallholder output ranged from 35 percent to over 60 percent from 1970 to 1986 and is only slightly lower as a percent of the value of all agricultural output, including that of estates.

The nutritional implications of the dominance of maize calories in the diet[10] and soil fertility implications of monocropped maize have been cause for policy concern. Releasing land for the production of other foodcrops and potential cash crops is now a priority for nutritional, soil fertility, and income reasons—at a national and a farm household level. However, the fact that the majority of farm households are maize deficit may mean that the most that can be accomplished through improving maize yields in the short to medium term is to close the household food deficits, reduce the threat of food imports, and slow the expansion of maize area.

[10]Ferguson et al. (1990) argue that "in the absence of agricultural inputs that stabilize production, declines in crop diversity may result in greater nutritional risk at least for certain strata of farmers" (p. 276).

4. An Inventory of Varietal Innovations

Until the early 20th century, the maizes grown in the region were small-statured, flint types with shorter season materials grown on alluvial soils and swampy areas during the dry season and longer season varieties cultivated as part of the rainfed crop complex (Blackie, 1989). According to Miracle's (1966) historical description of maize in tropical Africa, flinty varieties were, until recently, more popular than denty varieties because of lower susceptibility to insect infestation.

Although dent hybrids cover almost all maize area in Zimbabwe and over two-thirds of maize area in Kenya, flinty local varieties still predominate in southern Tanzania, eastern Zambia, and Malawi. The trade-off between dentiness and flintiness is related in part to yield and in part to the supply of germplasm. To this date, suitable breeding material for dent hybrids is much easier to locate and the resulting hybrids that have been produced have superior yields.[11]

An approximate time chart and description of varieties released by Malawi's maize breeding program is shown in Table 4.1.[12] Perusal of the maize types released and imported over the years illustrates how the emphasis of the breeding program has oscillated between, but has always included, both hybrids and OPVs. Related to maize type is the issue of dent and flint characteristics.

Brown (1963) writes that prior to independence, very little mass-selection had been done by farmers. In the 1940s, S. Hoyle began collecting, identifying landraces and inbreeding local material to produce pure lines. In 1954, R.T. Ellis initiated a breeding program which led to the development of a number of hybrids and several synthetics. Among these, the best cultivars (subsequently released) were considered to be LH11, a semiflint hybrid, and three semiflint synthetics (SV28, SV17, and SV37). Each synthetic was bred for a distinct region and agroclimatic zone.

Breeding activity appears to have ceased almost completely during the early 1960s with the transfer of power. Breeding lines deteriorated and, in 1967, the hybrid program was officially discontinued. When the new breeder, Bolton, arrived from Tanzania in 1970, the emphasis of the program shifted from synthetics to composites. Bolton and other officials brought materials from Kenya, Tanzania, and Zimbabwe. The program released the composites UCA ("Malawianized" from Tanzanian material) and CCA (developed primarily from local materials), but imported the hybrids SR52 (Zimbabwean), R200 (Zimbabwean), and H632 (Kenyan).

In 1977 the hybrid program was restored. In response to the popularity of SR52 in other countries of the region and among estates in Malawi, and to reduce exorbitant import costs, program researchers began screening Zimbabwean and South African hybrids with the ob-

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[11]An example is the difference in yields reported by Bolton (1974) for LH11 and SR52. Part of the yield difference between LH11 and SR52 is due to the fact that LH11 was a double-cross and SR52 is a single-cross hybrid. Breeders may have also been unduly influenced by North American studies that show a slightly higher yield potential (approx. 5 percent) for dent maize.

[12]Sources include Kydd (1989), Bolton (1974), Kettlewell (1965), Darrah and Penny (1974), and oral interviews with B.T. Zambezi, Senior Maize Breeder and Maize Commodity Team Leader. The information is approximate.

Table 4.1 Source, Flint Content, Type, and Approximate Release Dates of Maize Varieties in Malawi

Year	Name	Flint Content	Type	Source
1959	SV17	semiflint	synthetic	Bred locally
1961	LH11	semiflint	hybrid	Malawi-Mexican-Zimbabwean inbred lines, bred locally
1966	SV28	semiflint	synthetic	East African Agriculture and Forestry Research Organization inbred lines, bred locally
1967	SV37	semiflint	synthetic	Bred locally
	SR52	dent	hybrid	Imported, Zimbabwean-bred
	R200	dent	hybrid	Imported, Zimbabwean-bred
1971	UCA	semiflint	composite	Tanzania-bred (adapted)
	CCA	semiflint	composite	Local materials/some exotic, bred locally
	HG32	semident	hybrid	Imported, Kenya-bred (LLDP only)
	R201	dent	hybrid	Imported, Zimbabwean-bred
1978	MH12	dent	hybrid	(Adapted) Zambian SR52
1983	NSCM41	dent	hybrid	Ciba-Geigy 4141, import license for F1
1984	MH14–16	dent	hybrid	RSA-Zimbabwean germplasm, bred locally
	CCC	semiflint	composite	Local, CIMMYT, RSA and Zimbabwean material, bred locally
	CCD	semiflint	composite	IITA/CIMMYT/RSA material, bred locally
	R215	dent	hybrid	Imported, Zimbabwean-bred
	Tuxpeno		composite	Imported, CIMMYT
	Kalahari Early Pearl		composite	Imported, RSA-bred
1990	MH17	semiflint	hybrid	MH12 and CIMMYT material, bred locally
	MH18	semiflint	hybrid	MH16 and CIMMYT material, bred locally

jective of selecting high-yielding hybrids to replace SR52. Their work culminated in the release of MH12 and the development of breeding lines for MH14–MH16. That decision marks a change in emphasis to breeding for yield with dent hybrids, although the importance of flintiness was still recognized in continued work with composites. In the mid- and late 1980s, length of growing season emerged as a research theme. The semiflint, shorter season composite CCD and shorter season denty hybrid MH16 were released. The dent hybrids NSCM41, R201, and R215 were also imported.[13] Only in the past few years were the themes combined in the rapid development and release of two new semiflint hybrids, MH17 and MH18, one of which (MH18) has a relatively shorter growing season.

[13] There is perpetual debate about the flintiness of these varieties. Although some farmers report that they process better than other dent hybrids, the breeders always rank them at the same point as other hybrids on the flint-dent spectrum.

5. The Impact of Maize Research

Just before independence, Brown (1963) described maize as the staple food, called it a subsistence crop, and reported that it was grown on ridges laid out in contours and cultivated by hoe. Based on the estimates reported in Kettlewell (1965), about 0.6 million hectares were cultivated in maize. Kettlewell's yield estimates were 0.7 t/ha for the North, 1.1 t/ha in the Central Region, and 0.9 t/ha in the South. Weighted by area, Kettlewell's figures suggest an average unfertilized maize yield of 0.9 t/ha. Assuming no exports and using a figure of 1.1 tons/annum for the maize subsistence requirements of a family of four, Brown estimated that a maintained national yield of 3 to 4 t/ha was a reasonable research objective to assure maize self-sufficiency.

Today, hand-hoe cultivation with ridging is still the dominant form of land preparation except in some areas of the North where farm sizes are relatively large and labor requirements correspondingly burdensome (ASA and CIMMYT/MOA). About twice as many hectares are sown each year to maize, and the population has more than tripled. To meet the same maize subsistence requirements on the same maize area reported by Brown, average maize yields would need to be nearly 7 t/ha. Given current estimates of minimum per caput maize requirements (230 kgs), average maize yields of 3 t/ha would meet the same objectives while permitting land to be diverted for the production of other food and cash crops. Data on national yields show a positive trend, but only when taken over a long time period (FAO and USDA).

A comparison of similar figures and point estimates has suggested to some that little has changed since the breeding program began (Kydd, 1989). On the contrary—given a rapidly growing population and the dominance of maize in the diet, the impact of maize research and gradual HYV adoption has clearly been to counteract the yield-reducing effects of declining soil fertility and expansion into marginal lands, enabling the nation to continue to be, in most years, self-sufficient in maize. National maize yields, at approximately 1.3 t/ha, are probably far short of research goals, but national hybrid maize yields (of smallholders) are roughly 3 t/ha. In the high-potential adoption zones such as parts of Mzimba District, the Kasungu, and Lilongwe plains, average maize yields have, in fact, increased. Today's average maize yields for the major maize-producing zones would be closer to 1.3 t/ha for the North, 1.5 t/ha in Central Region, and 1.0 t/ha in the South.[14] In contrast to the point estimates computed for the colonial period, average yields for unfertilized local maize appear to have probably declined to approximately 0.7 t/ha (CIMMYT/MOA).

As in other HYV adoption settings (Blackie, 1990), *initially* the main beneficiaries of maize research have probably been larger producers and smallholders on better quality land. These farmer subgroups enjoy management or physical resource advantages and are better positioned to bear the economic risk of using credit and experimenting with new varieties. Recorded in case studies during the 1970s and 1980s, the larger farmer bias may have been especially true in the early years of the Lilongwe research and extension program and in various pilot efforts (Roberts, 1972; Chipande, 1987; Hansen,

[14]Based on National Crop Estimates for the late 1980s.

1986; Anderson, 1975). Based on the seed sales estimates reported by Quinten and Sterkenburg and FAO area figures, 0.3 percent of aggregate maize area in Malawi was sown to hybrids in 1970/71, of which about two-thirds of the area was located in Lilongwe District and most of the seed was imported. The same sources provide estimates of 2.3 percent of aggregate maize area under first-, second-, or third-year synthetics with two-thirds of the area again in Lilongwe District. A Lilongwe Land Development Programme (LLDP) survey in 1971 showed 53 percent of farmers growing synthetics and 17 percent sowing hybrids.[15] One source cited by Kydd (Schulten and Westwood, 1972) estimated as much as 8 percent of total cropped area was planted to improved varieties (mostly synthetics) in the early 1970s. At perhaps the peak of composite maize diffusion, the 1980/81 NSSA shows a fairly significant percentage of smallholders growing composite varieties in Mzuzu, Kasungu, and Salima ADDs.

Over time, as in Zimbabwe and Kenya (although much more slowly), a larger subset of farmers have been able to adopt recommended varieties on part of their maize area, with and without credit or project schemes. The upward slope in the aggregate diffusion curve for hybrids and broadening in the cross-section of adopters is especially evident in the last three years (Smale et al., 1992; FSNM). Econometric results, descriptive statistics, and secondary sources suggest that multiple factors are associated with the propensity to adopt. Farmer learning, greater willingness to substitute denty hybrids for local maize in consumption, shorter growing season and lesser yield risk with hybrids, as well as institutional factors such as improved seed distribution and greater flexibility in package diffusion, have undoubtedly contributed to growing adoption rates in the last few years (Smale, 1992). The effects of the latest research breakthrough—the release of two new semiflint hybrids—are now being assessed (Smale et al., 1993; Jones and Heisey).

The following subsections use the CIMMYT/MOA and ASA survey data to portray some of the likely effects of hybrid maize adoption on farm households, between ADDs, and on various national economic indicators. Survey zones and ADDs are shown in Map 1. The narrative focusses on hybrids for several reasons. First, there are obvious difficulties in measuring the amount of improved OPV material in farmers' fields and associated technological impact. Second, seed sales, secondary sources, and the two survey data sources suggest that the area under first-year OPVs has been declining over the past decade, while the area under hybrids has increased. Third, for better or for worse, today's emphasis of the maize research program, largely enforced by donors, is hybrid development. However, any hypothesized research impact is recognizably understated if it excludes synthetics and composites. For example, first-year composites, as compared to hybrids, continue to be grown on about 10 percent of maize area in Salima ADD, a primarily lakeshore environment. The impact of all composite material in Salima is of course greater than that figure indicates.

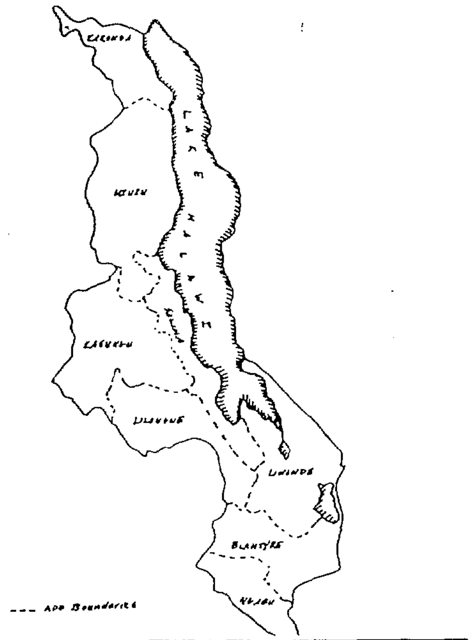
Farm Family Impact

Household Characteristics of Adopters and Nonadopters

In the 1989/90 season, all but a few survey farmers grew local maize. In Kasungu and Mzuzu survey zones, over a third of farmers also grew hybrid varieties, but in Blantyre only 14 percent sowed hybrid maize. Even when farmers planted hybrids they continued to devote the major portion of their maize area to local maize. Both adopters and nonadopters

[15] An interesting item reported in the survey report was that when hybrid maize growers were asked why they continued to grow local or synthetic varieties, one of their responses was a "stated loyalty" to a certain acreage of local *and synthetic* varieties.

Map 1. Agricultural Development Divisions of Malawi



preferred to consume local maize, although some substituted their own or purchased hybrid maize during maize-deficit seasons.

Those who adopt are more likely to be male, members of credit clubs, and to operate larger areas (Table 5.1). Wealth influences opportunities for adoption, and credit relaxes expenditure constraints, facilitating adoption—if only for a season. The larger the land area, the more likely is the household to qualify for credit or to have alternative crops that generate cash income. Female heads of households who are divorced or widowed tend to be less wealthy and are less likely to be club members—and therefore have fewer opportunities to adopt. The primary diffusion mechanism for the seed-fertilizer technology package has been the formal credit system, which has favored joint households and larger farms. This interrelated cluster of factors, which often translates loosely into "control over resources," is associated with the probability of adoption but disguises diversity in the adopter population.

The figures also demonstrate that female-headed households, noncredit club members, and smaller farmers do adopt. Certain cultural traditions imply de jure female-headed households are more prevalent in the South where farm sizes are also smaller.[16] Women in that region generally have matrilineal rights to land, but small farm size has constrained their choices. Given consumption preferences and, until recently, recommendations for growing hybrids in pure stands where intercropping is more prevalent, many women probably didn't feel they had "enough land" to grow hybrid maize (Hirschmann and Vaughan, 1983). Maize is clearly a woman's crop to the extent that it is a food crop, but in any region, all members of the household, when present, work in the maize fields. Hybrid maize purchased on credit may be more of a "men's crop" in the North, for example, where cultural traditions are also patrilineal. In no sense, however, is the concept of "women's crops" and "men's crops" particularly useful in the analysis of hybrid maize adoption in Malawi.[17] Producing sufficient maize is the common objective of every individual in any Malawian household.

Anecdotal evidence from the 1989/90 CIMMYT/MOA survey illustrates what differences in farm size among adopters implies. Farm size is related to farming systems and farmer objectives, and not just to credit eligibility. One of the subsets of hybrid maize growers was found in Thyolo. These farmers grew short-season hybrid maize on tiny plots to consume or sell green in Blantyre city for supplementary food or cash during the hungry season. They also worked off the farm to meet their

[16]Peters' distinction between *de facto* (male absent and engaged in employment activities) and *de jure* (divorcee or widow) female-headed households is appropriate in explaining different probabilities of adoption.

[17]Even in Zomba, Peters concludes that there are no gender-linked crops in the way the concept is used to describe West African systems (1989).

Table 5.1 Relationship of Farm Household Characteristics and Hybrid Maize Adoption

Household Characteristic/ Subgroup	ADOPTION CHARACTERISTIC: Percent of Subgroup Sowing Hybrid Maize	Mean Percent of Maize Area Sown in Hybrid Maize by Adopters
Sex of Household Head*		
female	17	39
male	38	43
Credit Club Membership*		
yes	76	44
no	17	40
Farm Size Class*		
less than 0.7 ha	13	44
0.7 to 1.5 ha	36	44
more than 1.5 ha	56	37
Local Maize Subsistence Ratio+		
less than 1	33	30
1 or above	40	48 **

* statistically significant differences between subgroups (5 percent), chi-square test.
** statistically significant differences between subgroups (5 percent) t-test.
\+ actual local maize output/minimum stated maize subsistence requirements.

Source: Maize Variety and Technology Adoption Survey, CIMMYT/MOA, 1989-90.
N=420 farmers in Blantyre, Mzuzu, and Kasungu Agricultural Development Divisions.

local maize consumption needs and to buy their inputs. By contrast, some of the hybrid maize growers in the Kasungu and Mzuzu areas sold over 2 tons of hybrid maize in the previous year, producing 3 to 4 t/ha yields by applying high analysis fertilizer and using animal draft power for land preparation. These farmers also had enough land to produce large outputs of local maize, satisfying their consumption requirements at the same time that they earned profits from their hybrid maize. Both sets of farms may have grown hybrid maize for different economic reasons.

Noncredit club members also adopt. In 1989/90, hybrid maize adopters in the Blantyre survey zone were more likely to be self-financed and to have first learned about improved seed from other farmers rather than extension agents. The fact that, in the past, credit packages have consisted of seed and fertilizer in fixed quantities also means that land allocated to hybrid maize by credit users has exhibited a lumpiness around 0.4-ha (1-acre) intervals. For hybrid maize growers who are not credit club members, there is greater variation in hybrid maize hectarage.

Table 5.2 Local Maize Yields, Hybrid Maize Adopters and Nonadopters
(kilograms per hectare)

Characteristic	Subgroup	
	Adopters	Nonadopters
Mean observed maize yields, objective yield estimates		
Unfertilized local	832*	720*
Fertilized local	1,351*	1,184*
All maize	1,806*	881 *
Mean expected maize yields, farmers' estimates		
Unfertilized local	853*	704*
Fertilized local	1,536*	1,317*

*Statistically significant differences between subgroups (5 percent), t-test.
N = 420 farmers in Blantyre, Mzuzu, and Kasungu Agricultural Development Divisions.

Source: Maize Variety and Technology Adoption Survey, CIMMYT/MOA, 1989–90.

The CIMMYT/MOA data also confirm that in Malawi, adoption patterns, sex of household head, farm size, and credit club membership vary by zone. In aggregated figures, differences in these variables as they relate to adoption are to a large extent differences associated with agroeconomic zone. Within zones, differences are less evident. For example, within the Blantyre survey zone female-headed households were no less likely to adopt than male-headed households while in the Mzuzu zone, they were. Similarly, although pronounced among the Kasungu and Mzuzu survey farmers, differences in the likelihood of adoption between farm size classes were not significant among the Blantyre survey farmers.

Finally, sex of household head, credit club membership, and farm size may affect probabilities of adoption, but are less likely to influence the proportion of maize area adopters plant in hybrids. The household characteristic that is more likely to affect land allocation to varieties by adopters is the ratio of local maize subsistence requirements to the local maize output their land can produce.

Management Practices of Adopters and Nonadopters

Adopters in the survey zones both obtained and believed they could obtain higher yields from their local maize (Table 5.2). Partial explanation for this finding is provided by evidence that adopters were more likely to apply fertilizer to their local maize and, when they used it, they applied a higher rate of N/ha (Table 5.3). Often farmers reallocate some of the fertilizer received on credit as part of a hybrid maize or tobacco package to their local maize, but in recent years fertilizer has been available on credit specifically for local maize and some club members purchase additional fertilizer with cash.

Fertilizer application does not explain all of the difference between actual and observed local maize yields for adopters and nonadopters,

Table 5.3 Fertilizer Use on Local Maize, Hybrid Maize Adopters and Nonadopters

Characteristic	Subgroup	
	Adopters	Nonadopters
Percent of farmers applying fertilizer to local maize**	79	39
Mean kgs N per hectare, farmers applying fertilizer to local maize	49*	32*

* Statistically significant differences between subgroups (5 percent), t-test.
** Statistically significant differences between subgroups (5 percent), chi-square test.
N = 420 farmers in Blantyre, Mzuzu and Kasungu Agricultural Development Divisions.

Source: Maize Variety and Technology Adoption Survey, CIMMYT/MOA, 1989-90.

however. The fact that unfertilized local maize yields differ between the groups suggests that other management or human capital variables may play a role.

Between varieties, as expected, farmers devote more labor to land preparation for hybrid maize because they more frequently plant it on fallowed land (Table 5.4). Although hybrid maize tends to be planted later, more time is required in planting because of greater planting densities and, according to many survey farmers, because "greater care is needed to follow recommendations." More hybrid area than local maize area is also weeded twice.

Resource Availability and Allocation, Adopters and Nonadopters

Adopters tend to have both larger total areas and larger areas in other crops (Table 5.5). Although, on the average, maize as a percent of household cultivated area differs statistically between adopters and nonadopters (because of small standard errors), the difference is hardly meaningful. Even after farmers have adopted hybrid maize, they continue to sow a large portion of total cultivated area in maize both because of the dominance in the diet and the economics of the cropping system. In general, hybrid maize area substitutes for local maize area rather than releasing land for cultivation of other crops. Per hectare net returns are probably higher in most years for hybrid maize than for many of the alternative crops smallholders can grow (groundnuts, beans, cassava, sweet potato). In Mzimba District of the Mzuzu zone, hybrid maize is a cash crop. Among the survey zones, perhaps the greatest reallocation of farmers' area is found among Kasungu farmers who have the opportunity to grow highly remunerative tobacco. Kasungu farmers were also more willing to consume their own hybrid maize.

The farms of adopters also have greater carrying capacity (hectares per adult over 12 years of age) to support the starchy staple needs of the family. The very slow decrease in the percent of farm area sown to maize as the labor/land ratio rises underscores the importance in farm household objectives of attempting to satisfy maize subsistence requirements.[18] Controlling for farm size and labor capacity does not diminish the most salient feature of

[18]The significance of the subsistence constraint in farm household decision-making is supported by several types of econometric results (Smale, 1992).

Table 5.4. Selected Agronomic Practices, Local and Hybrid Maize

Characteristic	Maize Variety	
Land Preparation	Local	Hybrid
Percent of plots sown after fallow**	4	10
Percent of plots ridged by ridger**	9	15
Planting		
Percent of plots planted after Dec. 15**	17	27
Mean plant density (1000/ha)	31*	35*
Weeding		
Percent of aggregate area weeded twice	63	76
Intercropping		
Percent of aggregate area intercropped	16	13

*Statistically significant differences between subgroups (5 percent), t-test.
**Statistically significant differences between subgroups (5 percent), chi-square test.
N=420 farmers in Blantyre, Mzuzu, and Kasungu Agricultural Development Divisions.

Source: Maize Variety and Technology Adoption Survey, CIMMYT/MOA, 1989-90.

Table 5.5 Resource Availability and Allocation Indicators, Hybrid Maize Adopters and Non-Adopters

Characteristic	Subgroup	
	Adopters	Non-Adopters
Mean farm size (ha)	1.68*	1.07*
Maize area	1.42*	0.92*
Area in other crops+	.26*	0.14*
Mean hectares/adult (< 12 yrs)	.60*	.41*
Mean percent of cultivated area in maize	86*	90*
Hectares/adult class	Percent area in maize	
> 0.25	95	95
.25 to .39	86	92
.40 to .59	85	86
< .60	85	83
Mean annual earnings from off-farm labor (MK)	136	143

+ Defined by primary crop
* Statistically significant differences between subgroups (5 percent), t-test.
N=420 farmers in Blantyre, Mzuzu, and Kasungu Agricultural Development Divisions.

Source: Maize Variety and Technology Adoption Survey, CIMMYT/MOA, 1989-90.

Table 5.6 Maize Importance in Household Income and Consumption, Hybrid Maize Adopters and Non-Adopters

Characteristic	Subgroup	
	Adopters	Non-Adopters
Mean value of crop output (MK)	899*	363*
Maize output	743*	257*
Other primary crops	127*	62*
Other crops interplanted with maize	29**	44**
Maize as percent of value of primary crops (MK)	86	87
Maize as percent of value of annual income (MK)+	65*	49*
Mean maize output (kgs) per adult (< 12 years)	942*	314*
Mean minimum annual maize subsistence requirements (kgs)	1,067*	982*
Mean minimum annual maize subsistence requirements (kgs) per hectare	947*	1,394*

+ Annual income defined as sum of off-farm wage and in-kind earnings, livestock sales, value of primary and interplanted crops produced, remittances and value of maize stocks at planting.
* Statistically significant differences between subgroups (5 percent), t-test.
** Statistically significant differences between subgroups (5 percent), t-test.
N=420 farmers in Blantyre, Mzuzu, and Kasungu Agricultural Development Divisions.

Source: Maize Variety and Technology Adoption Survey, CIMMYT/MOA, 1989-90.

farming systems in Malawi (Table 5.5).

When cultivated following recommendations and even when adapted to most farmers' conditions, farmers use more labor per hectare for hybrid maize than for local maize varieties as they are typically grown.[19] On the average, however, adopters do not appear to reallocate labor from off-farm to farm activities but within farm activities (Table 5.5).

[19]There is no particular reason why high levels of management could not be applied to fertilized local maize as well!

Household Income and Consumption, Adopters and Nonadopters

The mean value of total crop output for adopting households is 2.5 times the value for nonadopters, primarily because of increased maize output, but also as a result of their other crop production. The importance of maize as a percent of the total crop value is the same for both groups, while maize as a proportion of total annual income flows increases in significance for adopters (Table 5.6).

Average maize output per adult triples with hybrid maize adoption. Mean minimum annual maize subsistence requirements are higher for the adopting households because they tend to be larger; however, because their farm sizes are also greater, the amount of maize per hectare they need to produce to meet their requirements is lower. Consequently, adopting households are better off both with respect to absolute maize output and maize output relative to requirements.

The boost in maize output could, other factors held constant, imply improved caloric intake and, through maize sales, a diversified diet (more oils and protein) for adopting households. Other factors are likely to dilute, but not offset, the apparent consumption and nutritional gains. First, because many of the adopters are club members, some of their hybrid maize output is used to repay loans. Even when hybrid maize is not sold to repay loans, denty hybrids were usually sold to meet cash needs because of their poor storability and processing characteristics and may have had less of a direct effect on nutrition than the new semiflint hybrids. To the extent that local maize is more frequently intercropped than hybrid maize, growing hybrid maize could have a slight negative effect on nutrition. Since most adopters also grow local maize and, in zones where intercropping is frequent, hybrid maize is increasingly intercropped, the last effect is likely to be negligible.

As a positive effect of hybrid maize adoption on nutrition, farm households that grow earlier maturing hybrids are able to consume more green maize in the hungry season and harvest earlier. If it is true that *mgaiwa* (wholemeal flour) is more nutritious than *ufa woyera* (refined white or "pure" flour), adopting households who consume their own hybrid maize as whole grain flour may also receive some nutritional benefit.

Potentially, the food security position of hybrid maize growers could be less precarious, but the food security impact of hybrids is probably more evident on an aggregate than on a household level. Without the hybrid maize output marketed by adopters, maize-deficit households would probably have to pay higher maize prices in the hungry season—if they could procure maize at all. In part, the marketing system for hybrid maize has operated to redistribute the less preferred varieties, at a cheaper consumer price, from production surplus to deficit areas. When it is valued in terms of national food security, the shadow price of hybrid maize output is greater than its nominal value.

Yield and Economics Risks of Hybrid Maize Adoption

A comparison of either observed or expected cumulative yield distributions for fertilized hybrid maize, fertilized local maize, and unfertilized local maize demonstrate that the fertilized hybrids grown in Malawi are less risky with respect to yield than either fertilized or unfertilized local varieties. On the other hand, relative riskiness of net returns (one aspect of economic risk) depends on the pricing relationships assumed. If local maize is given a value premium expressing superior processing and storage efficiency, and households are assumed to produce local maize only for home consumption, fertilized local maize appears less risky than fertilized hybrid maize. When the conventional assumptions used to compare profitability are employed, the results are inconclusive and depend on the nature of individual farmers' attitudes toward risk. In other words, for *all* farmers, yield prospects are less risky with hybrids. For *some* farmers hybrid maize cultivation poses more of an economic risk than local maize production. The fact that no single technology dominates with respect to riskiness of returns suggests that farmers may be able to reduce total economic risk by sowing a portfolio of varieties.

The cumulative distributions also show that the total probability of negative returns, or "downside risk" is always greater with fertilized hybrid maize relative to fertilized or unfertilized local maize. When farmers operate with limited resources, producing a small sur-

Table 5.7. Labor Returns and Total Factor Productivity, Hybrids and Local Maize

Characteristic	Maize Technology Fertilized Hybrid	Fertilized Local	Unfertilized Local
Yield (kgs/ha)	2,774	1,264	745
Price (MK/kg)	0.29	0.29	0.29
Transport and harvesting costs	0.04	0.04	0.04
Gross Returns (MK/ha)	694.50	316.00	186.25
Seed Costs[1] (MK/ha)	37	6.5	6.5
Fertilizer[2]	196.35	72.1	----
Credit Charges	28.00	8.65	----
Variable Costs (MK/ha)	261.35	87.25	6.50
Gross Margins (MK/ha)	432.15	228.75	179.75
Gross Margins/Person-hour[3] (MK/hour)	1.16	0.66	0.59
Total Factor Productivity[4]	1.49	1.10	0.95

[1] 25 kgs/ha
[2] For hybrid maize, 170 kg/ha urea and 85 kg/ha DAP; for local maize, 75 kg/ha urea and 20 kg/ha DAP.
[3] Six-hour days; 62 person-days for hybrid maize, 58 person-days for fertilized local maize, and 51 person-days for unfertilized local maize.
[4] Rental rate for land = MK123.50 (Jere, 1990).
N=420 farmers in Blantyre, Mzuzu, and Kasungu Agricultural Development Divisions.

Source: Maize Variety and Technology Adoption Survey, CIMMYT/MOA, 1989-90.

plus in one year and a deficit in the next, the risk of low or negative economic returns may be of primary importance in their decision-making.[20]

Returns to Labor and Total Factor Productivity, Hybrids and Local Maize

Returns to labor in maize production for local maize (fertilized and unfertilized) and hybrid maize (fertilized) are shown in Table 5.7. The series have been constructed using experimental data for labor hours and CIMMYT/MOA survey data on returns, expenditures, and wages. The figures are comparable to, but lower than, those calculated in representative budgets by Planning Division, Ministry of Agriculture. Under farmer conditions in 1989/90, on the average, adoption of hybrid maize roughly doubled returns to labor in maize production.

Preliminary estimates of total factor productivity (the value of output divided by the total value of inputs) were also calculated for the three maize technologies.[21] Output, variable

[20] Details of method and construction for the above analyses are reported in Smale et al. (1992). Econometric evidence that sowing hybrid maize does not involve greater yield risk than sowing local maize in Dowa West, Kasungu ADD, is also found in Bulla (1990).

[21] Farm-level prices were used. No attempt was made to distinguish tradeables from non-tradeables, establish world market reference prices, or account for the effects of policy on relative prices. In addition to these caveats, prices do not include premiums for flint

inputs, and the rental rate for land were valued as shown in Table 5.7. Minimal capital costs were not valued. Estimated total factor productivity for unfertilized local maize is 0.95; for fertilized local maize 1.10; and for fertilized hybrid maize, 1.49. The figures suggest that unfertilized local maize, still the dominant technology, is relatively unproductive in Malawi's land-scarce conditions. Fertilization (at average rates for the sample) improves estimated total factor productivity by approximately 15 percent. Adoption of hybrid varieties plus fertilization increases it by over 50 percent. The predominance of maize in the cropping system even when total factor productivities are generally so low may be explained by the lack of alternative crops, the conventional pricing assumptions employed, or both.

For example, less conventional assumptions might reflect such considerations as (1) the majority of farm households produce less than their maize subsistence requirements; (2) yield losses in processing can be as high as 25 percent for denty hybrids; (3) storage losses for untreated denty hybrids are also very high; and (4) costs of procuring fertilizers are much higher for farmers who are not club members. With these assumptions, the comparisons of technologies favors fertilized local maize. The same calculations can be produced with various sets of assumptions (that are meant to characterize various farmer subsets) and generate contradictory sets of figures.

Agricultural Development Division Impact

Changes in Maize Technology

NSSA and ASA data sources provide maize technology information for the 1980s, but only case study information is available prior to that time. The NSSA figures show that the percent of farmers growing hybrids and composites in Malawi was roughly equivalent at 5 percent in 1980/81. In some ADDS such as Mzuzu, Kasungu, and Salima, around 10 percent of smallholders grew composites (Table 5.8).[22] Since that time the adoption rate for composites appears to have declined in the major maize-producing zones except for the 1990/91 season, while hybrid maize adoption rates show a net increase in all zones.[23]

The period toward the mid-1980s appears to have been rather sluggish, with the lowest adoption rates occurring in the 1986/87 season, the year following ADMARC's major financial crisis that created problems in purchasing hybrid maize from farmers. The last few years of data reveal perhaps the most rapid increase and the highest cumulative adoption rates recorded. Because farmers sow both varieties and allocate fairly small proportions of their individual farm area to hybrids, expansion of aggregate area sown to hybrid maize has grown at equivalent rates but has reached lower cumulative percentages (Table 5.9). Hybrid maize represents a large percentage of aggregate maize output, however. Because of measurement problems, the additional effect of composites on aggregate output through cross-pollination, as well as the direct effect, cannot be determined.

One interesting socioeconomic highlight of these figures is that although Lilongwe ADD was the principal focus of early promotional

character in local maize or consumption penalties for deficit producers. Results should therefore be treated with caution.

[22]Since composites are difficult to identify because of recycling, this figure can alternatively be interpreted as first-year composite seed. Recycling occurs when farmers retain grain from their harvest for use as seed in the following seasons. It is recommended that composites be recycled only once or twice.

[23] More recent aggregate adoption data for the subsequent seasons (not shown here) shows a continued upward trend. Data sources are described in Appendix A. Hybrid area estimates reported from the sample surveys for the last few seasons are also consistent with estimates derived from seed sales.

Table 5.8. Varietal Adoption Characteristics by Agricultural Development Division, 1980–1990

	Agricultural Development Division					
	Blantyre	Liwonde	Lilongwe	Kasungu	Mzuzu*	Salima
	Percent of farmers sowing hybrid maize					
1980/81	1	2	15	8	12	1
1985/86	1	--	12	27	24	--
1986/87	1	--	5	26	15	--
1987/88	4	--	9	--	20	--
1988/89	8	--	7	26	18	--
1989/90	14	--	22	33	38	--
1990/91	30	--	34	39	40	18
	Percent of farmers sowing composite maize					
1980/81	2	2	3	10	14	9
1985/86	2	--	1	1	3	--
1986/87	1	--	1	--	1	--
1987/88	2	--	0	--	2	--
1988/89	--	--	0	--	3	--
1989/90	1	--	2	1	2	--
1990/91	7	--	11	1	9	18
	Percent of farmers sowing local maize					
1980/81	98	98	99	95	--	74
1985/86	98	--	99	97	94	--
1986/87	99	--	99	95	99	--
1987/88	99	--	99	--	99	--
1988/89	--	--	99	97	99	--
1989/90	97	--	--	99	97	--
1990/91	98	--	--	96	99	--

* Excludes Nhkata Bay, a cassava-producing zone

Source: National Sample Survey of Agriculture, 1980-81, National Statistical Office, Government of Malawi; Annual Survey of Agriculture 1985-1989, Ministry of Agriculture, Government of Malawi; for last two seasons, CIMMYT/MOA Maize Technology and Varietal Adoption Survey, 1989-91, and Food Security and Nutrition Monitoring Reports 2 and 3, Ministry of Agriculture, 1990 and 1991.

efforts, by the 1980s both Kasungu and Mzuzu (excluding Nkhata Bay) ADDs had higher adoption rates but were far less studied. Until the last two seasons, hybrid maize adoption in Blantyre and Liwonde ADDs was hardly discernible. The geographical emphasis of social research on parts of Lilongwe, Blantyre, and Liwonde ADDS probably contributed to the misconception that hybrid maize adoption was negligible. In that context, perhaps the most surprising figures are those recently reported for Blantyre ADD.

Average maize yield figures illustrate differences among zones, not only because of higher adoption rates in Kasungu and Mzuzu for most years, but because hybrid maize yields

Table 5.9. Variety as Percent of Aggregate Maize Area and Aggregate Output, by Agricultural Development Division, 1980–1981

	Agricultural Development Division					
	Blantyre	Liwonde	Lilongwe	Kasungu	Mzuzu+	Salima
	Hybrid maize as percent of aggregate maize area					
1980/81	—	—	8	5	6	—
1985/86	1	--	7	15	16	--
1986/87	1	1	3	14	9	2
1987/88	2	2	7	11	13	2
1988/89	3	3	6	13	12	7
1989/90	6	5	11	13	22	10
1990/91	11	10	14	23	19	16
1991/92	11	11	20	19	19	16
1992/93	28	15	19	39	31	31
	Composite maize as percent of aggregate maize area					
1980/81	1	—	1	5	7	5
1985/86	3	1	—	1	2	11
1986/87	1	1	1	—	1	13
1987/88	1	1	—	--	1	16
1988/89	1	2	--	--	1	9
1989/90	1	3	--	1	2	10
1990/91	1	1	--	1	—	9
1991/92	2	--	--	1	--	6
1992/93	1	--	--	--	--	--
	Hybrids as percent of aggregate maize output					
1980/81	1	--	--	10	14	--
1985/86	2	--	15	24	35	--
1986/87	2	2	6	28	35	5
1987/88	2	4	16	22	26	7
1988/89	7	9	13	30	24	18
1989/90	18	16	26	44	47	28
1990/91	26	28	35	41	42	37
1991/92	22	39	47	40	52	40
1993/93	52	41	43	62	60	59

+ Excludes Nhkata Bay, a cassava-producing zone

Source: National Sample Survey of Agriculture, 1980-81, National Statistical Office, Government of Malawi; Annual Survey of Agriculture 1985-1989, Ministry of Agriculture, Government of Malawi; for last two seasons, CIMMYT/MOA Maize Technology and Varietal Adoption Survey, 1989-91; Government of Malawi, National Crop Estimates, 1985-1993.

Table 5.10. Mean Maize Yields by Variety, by Agricultural Development Division, 1980–1981

	Agricultural Development Division				
	Blantyre	Liwonde	Lilongwe	Kasungu	Mzuzu*
			Unfertilized local maize (t/ha)		
1980/81	1.0	0.8	1.0	1.1	0.9
1985/86	1.2	--	0.9	1.2	1.0
1986/87	1.1	--	1.0	1.1	1.0
1987/88	1.2	--	1.1	--	1.1
1988/89	1.0	--	1.1	1.3	1.1
1989/90	0.7	--	--	0.9	0.6
1990/91	0.8	--	--	1.2	0.9
			Fertilized Local Maize (t/ha)		
1980/81	1.6	1.1	1.8	1.7	1.4
1985/86	1.2	--	1.4	1.7	1.4
1986/87	1.8	--	1.6	1.7	1.3
1987/88	1.9	--	1.6	--	1.7
1988/89	1.5	--	1.7	2.1	1.5
1989/90	1.2	--	--	1.4	1.2
1990/91	1.4	--	--	1.6	1.6
			Fertilized Hybrid Maize (t/ha)		
1980/81	2.1	2.1	3.5	3.0	3.0
1985/86	2.8	--	2.6	3.0	3.3
1986/87	3.0	--	3.2	2.7	3.2
1987/88	2.3	--	3.7	--	3.2
1988/89	2.1	--	3.3	3.2	3.2
1989/90	2.2	--	--	3.0	2.9
1990/91	3.1	--	--	2.7	3.6
			All Maize (t/ha)		
1980/81	1.1	0.9	1.4	1.5	1.3
1985/86	1.2	--	1.1	1.6	1.5
1986/87	1.3	--	1.3	1.6	1.3
1987/88	1.5	--	1.4	--	1.5
1988/89	1.2	--	1.4	2.0	1.5
1989/90	--	--	--	--	--
1990/91	--	--	--	--	--

* Excludes Nhkata Bay, a cassava-producing zone

Source: National Sample Survey of Agriculture, 1980-81, National Statistical Office, Government of Malawi; Annual Survey of Agriculture 1985-1989, Ministry of Agriculture, Government of Malawi; for last two seasons, CIMMYT/MOA Maize Technology and Varietal Adoption Survey, 1989-91.

Table 5.11. Illustrative Welfare Changes for Hybrid Maize Adopters in Blantyre, Kasungu, and Mzuzu Agricultural Development Divisions, 1989–1991

Characteristic	Agricultural Development Division		
	Blantyre (MK)	Kasungu (MK)	Mzuzu (MK)
1989–90			
Mean net returns per hectare			
hybrid maize	381	533	455
local maize	178	238	186
Percent of total area sown			
hybrid maize	4	14	18
local maize	92	67	65
non-maize crops	4	19	17
1990-91			
Mean net returns per hectare			
hybrid maize	531	593	651
local maize	250	376	246
Average gross margins/ha for non-maize crops *	355	830	369
Percent of total area sown			
hybrid maize	11	16	16
local maize	86	54	66
non-maize crops	3	30	18
Inter-season welfare effects**			
hybrid maize effect	2,192	-868	-2,025
allocation effect	-639	20,169	1,070
interaction effect	56	-1,237	-162
net	1,609	18,064	-1,117
per adopter household	39	347	-21

* Weighted by area; figures are overstated because labor costs are not included.

** Assumptions and construction described in text; figures are for survey farmers only and totals are not expanded to survey zone.

Source: Maize Variety and Technology Adoption Survey, CIMMYT/MOA, 1989-90. N=420 farmers in Blantyre, Mzuzu and Kasungu Agricultural Development Divisions, with 140 farmers in each zone.

also appear to be lower in Blantyre (Table 5.10).[24]

An Example of Smallholder Welfare Effects

One way of depicting the total economic effect of changes in area sown to hybrid maize is to separate it into three components: (1) the percentage change in hectares sown to hybrid maize valued by the difference in net returns per hectare from sowing hybrid maize rather than local varieties; (2) the percentage change in hectares sown to nonmaize crops valued by the net value of nonmaize crop returns; and (3) the percentage change in hybrid maize area given no change in nonmaize area, valued by the difference in net returns per hectare from sowing hybrid

[24]Hybrid maize yield results for the years and zones with lower adoption rates may be a consequence of small subsample sizes.

maize rather than local varieties. The first (hybrid maize effect) is the simplest and most obvious measure of farmer welfare impact. The second (allocation effect) expresses the impact of reallocating land from maize to nonmaize crops, but carries the effects of other economic and technological variables than hybrid maize adoption and will therefore tend to be overstated. Unless there is a large increase in total cultivated area, the first and second effects should have opposite signs because they are substitutes. The third (interaction effect) "corrects" the hybrid maize effect by controlling for the effect of land reallocation, and will generally be fairly small in magnitude.

Results of calculations with the CIMMYT/MOA data are not realistic in absolute amounts but provide an example of how hybrid maize adoption affects farmers and agroeconomic zones differently (Table 5.11).[25] When total cultivated area is held constant, the area sown to hybrid maize increased and nonmaize area decreased only in the Blantyre survey zone. Consequently, the only positive hybrid maize effect between the two years is found in that zone. The negative effect of the small decline in hybrid maize area was greatest in Mzuzu, where the difference in net returns from growing hybrid maize is also greatest. The associated increase in nonmaize area is very large in Kasungu, and combined with average nonmaize returns that are several times as high because of tobacco revenues, the positive allocation effect dominates the total welfare effect. The meaning of the relative figures is clear. In Blantyre and Mzuzu, for different reasons, maize is a more dominant crop and the hybrid maize effect is correspondingly greater in magnitude than the other two components. In Mzuzu, where hybrid maize competes with other cash crops, a decline in hybrid maize area is likely to generate a relatively large welfare loss to farmers. In Kasungu where per hectare returns to tobacco are considerably higher than hybrid maize returns, the reallocation effect, to the extent that it measures land released by cultivation of hybrid maize instead of local maize, generates the largest welfare gain.

In other words, crudely speaking, the greatest potential impact of hybrid maize adoption in Blantyre is likely to be felt in a reduction of the household food deficits (especially if the hybrids are flinty);[26] the largest effect on Mzuzu farmers is in terms of cash crop production of hybrid maize; and in Kasungu, the most significant aspect of adoption is the land it releases for the production of more remunerative cash crops. The figures merely illustrate the notion that the welfare impact of hybrid maize adoption in Malawi is likely to vary dramatically by region, or farming system and farm household type.

[25]To separate and measure the effects, total cultivated area must be assumed constant. A reasonable assumption in gross terms, actual cultivated area figures do show some change over time - which weakens the welfare calculations. Conventional pricing assumptions were used, but could be modified to express various farm household scenarios as described above. Observed yields were used rather than expected yields, but these were very close at the mean, especially for local maize. Net returns were calculated from the CIMMYT/MOA data, and include labor costs for maize but not for non-maize crops, which further overstates the allocation effect.

[26]As noted above, parts of the Blantyre survey zone have characteristics that parallel the conditions described by Low (1986) for other zones in southern Africa. The Low model offers two reasons why subsistence producers may adopt hybrid maize. Deficit households will adopt hybrids if it is cheaper in labor time to produce staple requirements through growing more hybrid maize and purchasing less maize on the market - implying labor returns to own production are greater than returns in off-farm wage employment. Break-even households will adopt hybrids if fewer labor units are required to meet subsistence requirements and the marginal labor unit can be released to earn a higher return in off-farm employment than in farm production. Low emphasizes that, although hybrid maize adoption may result in a welfare improvement for adopting households, in neither case would adoption result in increased commercial production and marketed output.

National Impact

The general approach used to assess the national impact of maize research over time by no means provides an exhaustive account of research impact or rate of returns to research. Instead, it is based on the useful notion that, because of interactions and offsetting effects among underlying and exogenous economic variables, trends in aggregate production figures often disguise the extent of other changes induced by shifts in technology. The purpose of constructing various scenarios is to illustrate how certain key economic variables would have evolved with and without maize research.

For Scenario I, or the "actual" case, exponential trends are fitted to maize yield, area, production and consumption (availability) data to smooth fluctuations resulting from climatic conditions.[27] Net imports is the estimated residual of production less consumption and change in stocks. Agricultural GDP and GDP series are also fitted by exponential trends in terms of 1978 Malawi kwacha.

In Scenario II, or "static yield," yields are held constant at the 1961–65 average, maize area changes according to the "actual" trend, and per caput consumption is held constant at the 1961–65 average. Of particular importance is the fact that, because per caput maize availability exhibits a declining trend over time, the 1961–65 average is slightly higher (230 kgs/person) than the average for the 1986–1990 period (190 kgs/person). Net imports are then calculated as in Scenario I, as the residual from estimated figures. Agricultural GDP and GDP series are tabulated by adding the real value of maize production estimated under Scenario II to the "actual" agricultural GDP and GDP series from all nonmaize production.

Scenario II depicts the production, net imports, and GDP situation when farmers manage to use enough fertilizer to maintain maize yields despite declining soil fertility from maize monocropping over an extended time period. No new varieties are released. The GOM has a major policy goal of sustaining per caput maize availability at 230 kgs/person which is considered the minimum tolerable level of consumption. Production shortfalls relative to consumption requirements result in increased net imports. Maize area expands to further dampen the effects of declining soil fertility and temporarily buoy national production levels, with deleterious effects over the longer term because more marginal lands are opened and the economy becomes more dependent on a single crop. Under Scenario II, production reaches an asymptote as the proportion of total cultivable area sown to maize reaches 1 or all farmers apply fertilizer at their economic optimum, whichever occurs first.

Scenario III expresses "declining yield." Maize yields decrease at one percent per year from the 1961–65 average, area expands at the "actual" rate, and per caput consumption is held at the level consistent with food policy goals. Net imports and GDP figures are calculated by the same method described in Scenario II, with Scenario III production figures. In Scenario III, no fertilizer is used and no varieties are released. Population pressure and consumption preferences slowly deplete the land resource base with no offsetting technological change. The production, net maize imports, and agricultural GDP results for the three scenarios are shown graphically in Figures 5.1 to 5.3.

The effects on total GDP (not shown here) are similar to those on agricultural GDP, although lesser in magnitude. In Figure 5.1, actual yield trends combined with expansion of

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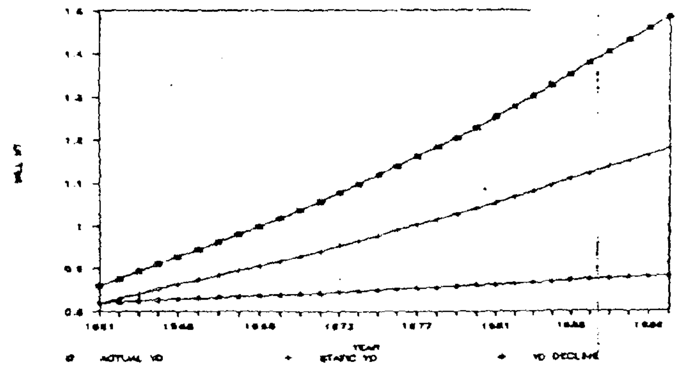
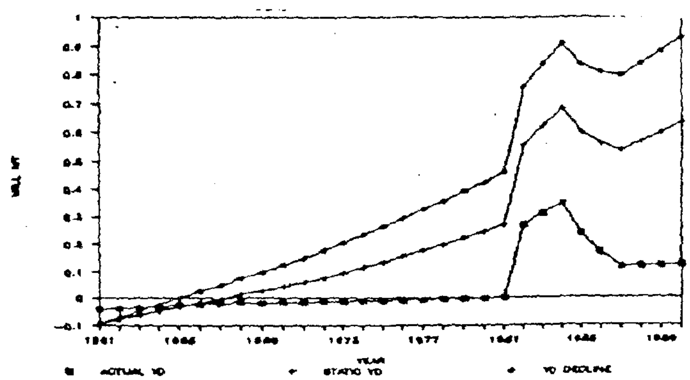
[27]Since there are no discernible distinct trends over subsets of the data years, exponential trends are close to those produced by 5-year moving averages, although smoother. Data for 1961 to 1990 is from U.S. Department of Agriculture, Economic Research Service for yield, production, imports, exports, consumption, and stocks variables. The GDP series and population series used to construct per caput consumption are from Pryor (1988). The real maize price series used to value production is from Gulhati (1989).

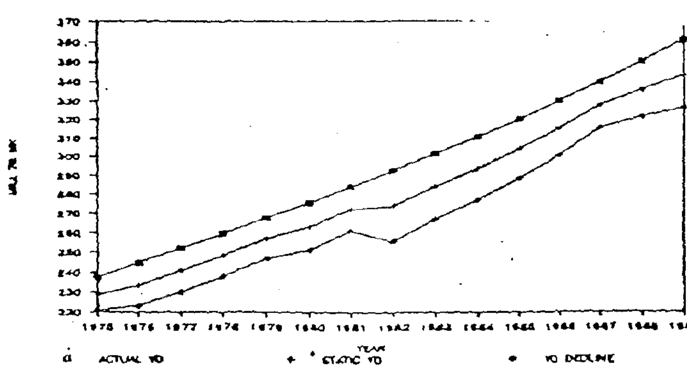
5.1. Malawi Maize Production—Three Yield Scenarios



5.2. Malawi Net Maize Imports—Constant Per Capita Consumption



5.3. Malawi Agricultural GDP—Three Yield Scenarios



hectares sown to maize causes national maize production to roughly double since 1961. That increase is approximately halved in the "static yield" scenario, with no maize research and limited use of fertilizer. In the "yield decline" scenario, maize production is nearly unchanged in 1990 from the 1961 level, and is kept at that level only through continual expansion of maize area. If maize area were held constant to express a policy goal of at least some diversification of crop output (recall that 1961 maize already occupied an estimated 66 to 75 percent of cultivated area), maize production would decrease in Scenario III.

If Malawi were autarkic (no trade), the results of either Scenario II or III on food security would be dramatic. Maize area would expand quickly to maximum cultivable area and there would be no means by which to sustain the population. Prices would rise prohibitively and the GOM would need increasing funds to subsidize consumer prices. To meet minimum consumption needs, even if Malawi trades, the effect of either static or declining yields is to increase net imports six- and tenfold in 1990 (Figure 5.2). If maize area expanded more rapidly to offset static or declining yields, the area devoted to alternative export crops would diminish and Malawi's agriculture-based economy would gradually become unable to finance the volume of imports. Even if maize area expanded at the "actual" rate, agricultural GDP would be cut by an average of 5 percent per annum in Scenario II and 9 percent per annum in Scenario III (Figure 5.3). Total GDP would be reduced by 2 percent and nearly 4 percent each year, respectively. There would be no recourse for the GOM but greater indebtedness, with little means for repayment.

A more complete macroeconomic model would be necessary to generate reliable quantitative estimates of research impact for the various scenarios, but the essential point remains clear in the case of Malawi. Without maize research and at least gradual technological change, the nation's food security and macroeconomic position would rapidly deteriorate. In an agriculture-based economy, and when both national agricultural production and individual producer livelihood is based on maize, maize research is critical. In that sense, the value of maize research cannot be overstated. The relevant policy issue is how to increase maize research impact by speeding the technology adoption process.

6. Factors Affecting the Impact of Maize Research on Varietal Adoption

High labor to land ratios, the significance of maize in the cultural and economic setting, and the relatively high ranking that Malawi enjoys with respect to some major development indicators,[28] suggest that conditions are favorable for varietal adoption. As shown by the adoption figures in Section V, until recently, changes in adoption rates have been gradual and overall levels fairly low. This section summarizes the complex of factors that are likely to have affected the extent and speed of the impact of maize research on varietal adoption in Malawi.

Varietal Preferences

Despite the many differences among the zones in the CIMMYT/MOA survey, farmers stated almost universally that they preferred local maize for consumption and consume their own or purchased local maize during more than six months of a typical year. Only one or two households in the full sample of 420 reported that they have changed their consumption preferences toward hybrid maize, despite the fact that over three-quarters of households in all zones consume their own or purchased hybrid maize during the hungry season or immediately after harvest, in years of poor local maize harvest or duress.[29]

The consumption preference for local maize is based primarily on its processing and storing characteristics, which reflect the flintiness of the varieties. The traditional processing method used to produce the socially preferred, fine white flour (*ufa woyera*) involves multiple stages and is labor intensive. Typically, the shelled maize is dehulled with a mortar and pestle, winnowed, soaked for lactic fermentation, dried, and pounded again by mortar and pestle or, increasingly, by hammermill. Some of the denty hybrids can be used to produce *ufa woyera*, but their relative softness leads to a lower flour extraction rate from shelled maize, and additional sand and water are often needed to create a proper pounding medium.

Otherwise, hybrid maize can be processed more quickly by hammermill and without lactic fermentation to produce a nutritious, although coarser and less prestigious flour (*mgaiwa*). During the colonial period, milled whole grain meal was typically fed to laborers and the inmates of hospitals, schools, and prisons. Refined flour with the bran added (for lack of better term, "homemade" *mgaiwa*) was not considered a suitable food for men, and "even women" were "often ashamed to admit that

[28]Sofranko and Fliegel (1989) concluded that Malawi ranks fairly high relative to other African nations with respect to such indicators as the percentage of the smallholder farm population using credit (now around 25 percent and higher in major maize-producing zones); the extension staff/farmer ratio; and the number and spread of buying and selling points for inputs (since decreased with the curtailment of ADMARC activities). However, they also found that the level of credit (MK/member) is low and that the same indicators also vary widely by region.

[29]Maize-deficit households are obliged to consume hybrid maize because most of the maize available on the official market during the hungry season is hybrid. Local maize can sometimes be purchased or obtained from other farmers through *ganyu* (labor exchange for seed or in-kind payment), but only a small percentage of farmers are surplus local maize producers, and even fewer are willing to part with local maize. Instead, it is often the poorer households who must sell a basket or a bag of local maize to meet some pressing cash needs.

they eat it." Despite that fact, *mgaiwa* was said to be "more sustaining than ordinary porridge, giving more strength for hoeing" (Williamson, 1956).

Observers of hybrid maize adoption patterns in Malawi and other zones where local varieties are flinty have often remarked that when labor-saving mills are widely introduced in rural areas, households will find it optimal to substitute milled grain for the traditionally preferred fine white flour that is so laboriously produced by hand-pounding methods. Yet almost all the women respondents in the CIMMYT/MOA survey have combined the traditional with the modern method. They continue to pound by hand, but where they used to pound two to three times, they now substitute grinding at the local mill for the final stage. The fact that women substitute grinding at the local mill only at the final stage of processing was noted as long ago as 1959.[30]

Preparation of maize for consumption remains extremely labor-intensive. Williamson's (1956) estimate of labor time in preparation was, for the first and second pounding only, about 12 to 13 hours, excluding dehusking, winnowing, soaking, washing, sieving, and related minor processing steps. The processing methods described by Williamson (1956) and by CIMMYT/MOA respondents (1991) were almost identical, differing only in that today, the second or third stage of pounding is usually replaced by milling. Even then, the time required to walk to the mill and wait in line may not be that much shorter than another stage of hand-pounding. A conservative estimate of labor time for flour preparation might be about 15 hours for five days of flour (an average family size).[31]

Use of secondary products from the process may still be important to many rural women and may contribute to their choice of pounding methods. Williamson (1956) cited a number of joint products of the traditional processing method that are consumed by household members. When food supplies were plentiful, bran was fed to chickens, but during famine or the hungry season, more of the bran was consumed by household members. At any time, the bran was used to brew beer. Children and pregnant and lactating women often consumed by-products of the pounding process, such as discarded whole and broken grains, germ meal, or the fine bran mixed back into the refined white flour.

Despite the apparent strength of consumer preferences, some aspects of maize consumption have changed slightly over time. Most hybrid maize adopters in the CIMMYT/MOA survey stated that they occasionally consume a portion of their own hybrid maize harvest as a means of bridging food requirements, although less so in Mzuzu zone. A large percentage of adopters try to solve the problem by pounding differently, rather than by consuming *mgaiwa*. For example, women often pound hybrid maize with larger amounts of sand and water, for a shorter period of time, and soak it for fewer days. Some are more successful than others in producing an acceptable *ufa woyera*. The Blantyre households seemed comparatively more willing to consume *mgaiwa*, perhaps because they have less experience modifying their

[30]Ellis wrote that there had been "an enormous increase" in the number of small hammer mills in Nyasaland in previous years and more people could consume whole-meal flour "if they wished." He observed generally that the women still separated the *madeya* (bran) from the *mphale* (broken grain) in the mortar and took the *mphale* to the grinding mill to be made into flour.

[31]Another indicator of the processing time is found in a report produced by the Agroeconomic Survey (1982). In that report, of all staple foods in Malawi, maize has the highest value-added as a percent of the total value of the commodity. Using prices from a survey of local markets, AES concluded that the conversion of maize grain through fermented broken maize (*mphale*) to maize flour (*ufa*) more than doubles the price.

pounding methods or possibly because a larger proportion of them are food-deficit and have grown accustomed to consuming *mgaiwa* made from purchased maize in the hungry season. Most hybrid adopters consume their hybrid production soon after harvest rather than applying actellic, the recommended insecticide.

Farmers' hybrid maize output is not an unimportant factor in household food security, despite the prestige of *ufa woyera*, the lower extraction rates from processing hybrid for *ufa woyera*, and storage losses that occur when actellic is not applied. For the majority of farm households who purchase from ADMARC (the official marketing agency) rather than from other farmers, the CIMMYT/MOA data also indicate that the modal consumption period for hybrid maize over the past few years has been approximately two months across strata. Whether farm households like it or not, they have often been obliged by their production and market conditions to consume denty hybrid maize.

Flinty hybrids can increase the area hybrid maize adopters allocate to hybrid maize if they are more substitutable in consumption and storage than denty varieties. Those who are able to adopt but have not yet adopted may be more willing to grow a flinty hybrid than a denty hybrid. But flintier hybrids cannot relieve underlying expenditure constraints or inability to qualify for credit. Even those farmers who can afford to purchase inputs cannot be expected to relinquish their local sources of seed until they can rely on marketing institutions for timely, certain delivery of quality seed meeting their own specifications.

Whether or not varietal consumption preferences change over time will be affected not only by the release of flintier hybrids but also by the quality and characteristics of local seed. Certainly in regions where a number of imported varieties have been introduced in the past, cross-pollination has occurred. Where food-deficit households who are obliged to consume their seed actually sow denty varieties obtained as food, the degree of contamination of local maize must be noticeable to farmers. The 1991–92 drought severely reduced and altered sources of local germplasm. Under these conditions, over time, the polarity between the flintiness of local maize and dentiness of existing hybrids becomes less clear. Following the drought, the new semiflint hybrids may represent some of the flintier maize types available to small farmers.

The Role of Research[32]

Maize Research Themes and Priorities

The evolution of maize breeding themes in Malawi can be largely depicted in terms of two poles: flint as opposed to dent character and, by association, the issue of hybrids versus open-pollinated varieties. Although, as in most breeding programs, yield may emerge most frequently as the foremost objective, the history of Malawi's program is one in which, at various points in time and varying degrees of intensity, other breeding criteria such as grain traits and growing season have been considered. The concern for flintiness has also created an alternative definition of yield—yield from the mortar.

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[32]Much of the material in this section is drawn from written communication or oral interviews with individuals who have been involved with Malawi's maize research program but who are not responsible for interpretations and conclusions. They include members of the Maize Commodity Team: B.T. Zambezi, Breeder, J.D. Kumwenda, V.H. Kabambe, W.D. Sakala, Agronomists, R.B. Jones, Agronomist and J. Wendt, Soil Scientist; as well as M. Collinson, Economist, formerly CIMMYT/Nairobi; B. Gelaw, Maize Breeder, formerly CIMMYT/Nairobi and now CIMMYT/Harare; A. Hansen, anthropologist, formerly with the University of Florida project at Chitedze Research Station; E.J.R. Hazelden, Executive Director, National Seed Company of Malawi; P.W. Heisey, Regional Economist, CIMMYT/Malawi; G.Y. Mkamanga, former CARO; B.R. Ndisale, Research Economist, Department of Agricultural Research; L. Ngwira, Deputy CARO; K. Short, Maize Breeder, CIMMYT/Harare.

Flint vs. Dent

Flint character has been a recognized breeding object in Malawi since Ellis began the maize breeding program before independence, but with greater or lesser importance depending on the time period. Above the themes of rust-resistance, good husk cover, and low-carried cobs, "the question of whether to breed for a flint or dent maize was of first importance" in the early years of the program (Ellis, 1959, p. 251). While he acknowledged that the dent commercial hybrids tested in Malawi produced high cob yields and shelling percentages, Ellis emphasized that insect damage during storage and local preferences were of major concern. As shown in the time chart in Table 4.1, the best among the first hybrids (LH11) and the synthetics (SV17, SV28, SV37) he bred were semiflints. Improving smallholder yield in consumption (net of crop damage, postharvesting and storage losses) rather than harvest yield was clearly what Ellis had in mind.

During the 1970s, Bolton appears to have interpreted the flint-dent question differently. In a 1974 article, he recognized the preference for white flint maize and the susceptibility of the dent SR52 (Rhodesian) to weevils in village storage conditions, but found that SR52 was "the highest yielding variety tested." By arguing that SR52 could be "successfully grown by cash crop farmers with good standards of crop husbandry" and "high fertilizer input," he implied that more well-endowed smallholders and estates should grow it as a cash crop (p. 108–10). When hybrid maize is produced as a cash crop and sold immediately after harvest, processing and storage losses do not reduce effective yield. To address the consumption needs of farmers who could not afford the cash outlays to purchase seed in every season, Bolton bred semiflint composites. The reason for producing semiflint rather than flint OPVs was that flints tend to produce small rounded kernels with low test weight. The idea behind OPVs was gradual change, at lesser expense for farmers.

The late 1970s and early 1980s appear to have been a period when new importance was attached to the indigenous production of hybrids, in part as a result of the continued popularity and yield advantages displayed by SR52 in southern Africa. Large commercial farmers who produced hybrid maize for sale or as food for laborers rather than for their own consumption, demanded the importation of the high-yielding, denty SR52. After borders were closed in Rhodesia with the Unilateral Declaration of Independence, SR52 was air-freighted into Malawi at exorbitant cost. Pressure to replace imports led to the release in Malawi of MH12, based on Zambian SR52 material, which yielded less than the Rhodesian version because the lines had lost their purity.

Dent character was necessarily associated with the demand for hybrids. Even in other parts of the world where maize is used in human consumption more than as animal feed, dent varieties have been preferred because they are more suitable for large-scale processing by roller mills (Kydd, 1989). The fact that global maize-breeding activity has concentrated on dent hybrids also limits the range of germplasm available for breeders seeking flint materials. Technology development in southern and eastern Africa has been restricted by the belief that dent maizes have higher yield potential than flints—in part a result of the early research breakthroughs with U.S.-bred dent materials (Blackie, 1989). While dent germplasm was "on the shelf," flint lines would have required seven years to develop.

Not only was breeding dent hybrids easier, cheaper, and faster, but there were arguments for promoting dent hybrids over flint varieties (Kydd, 1989). Although the colonial researchers cited by Ellis and Williamson argued that *ufa* was more nutritious than *mgaiwa* because of lactic fermentation and other characteristics, most nutritionists since that time have insisted on the superiority of *mgaiwa*. A second argument was that the prevalence of mechanical mills in rural areas would change consumer preferences because women would prefer to conserve labor time. Researchers were told that the urban roller mill operators, who were seen as the fastest growing component of the market for smallholder maize surpluses, preferred dents as being less injurious to their machinery. Another argument was that the insecticide necessary to protect dent hybrids in storage is cheap compared to the yield loss associated with flint hybrids. In any case, some of the breeders posted to Malawi may have discounted complaints of storage losses because it is generally true that HYVs have higher postharvest losses simply as a result of poor adaptation to traditional storage methods (Lozano and Leopold, 1988).

In the early 1980s when the Malawian maize breeders left for long-term training, lines for both the dent hybrids MH15 and MH16 and the semiflint composites CCC and CCD had been established. When they returned in 1986, pressure had accumulated, primarily on the part of donors, to produce flint hybrids. In the late 1980s, flint character became once again a principal breeding objective, for *both* hybrids and OPVs.

The earlier notion of promoting dent hybrid maize as a cash crop undoubtedly had implications for which groups of smallholders adopted hybrid maize (Gilbert et al., 1982) and cumulative adoption rates. From farmers' perspectives, different decision-making criteria are associated with cash crop and food crop production. From a development perspective, different resource sets are required for profitable production of high-management cash crops. Promotion of hybrid maize as a cash crop in effect reduced the ceiling adoption rate.

Hybrids vs. Open-Pollinated Varieties

Lipton (1988) has written that, although maize breeding "successes" have depended mainly on hybrids, in much of sub-Saharan Africa composites and synthetics make more sense but have been much less researched. In Malawi, both hybrids and OPVs were bred since the late colonial period, although at certain times influential players in the breeding process (donors, an individual breeder, the national seed company) appear to have strongly favored either hybrids or OPVs. Some of the debate over OPVs and hybrids seems to have been associated with the involvement of expatriate breeders and external agencies, and has undoubtedly been counterproductive.

For example, when Bolton came to Chitedze in the 1970s, the popular view among development agencies was that hybrids were only appropriate for larger farmers and progressive, commercialized smallholders. Bolton emphasized indigenous development of composites over hybrids. In so doing, however, he also decided to replace rather than revive the late colonial synthetics, whose lines had deteriorated after independence. In one set of experimental results, he specifically compares LH11, SR52, Ellis' synthetics, his own CCA and 'Malawianized' UCA. He concludes that not only is SR52 "the best yielder" and that "all four Malawi synthetic varieties...were inferior to the new composites," but that at least two of the synthetics should be dropped from the seed multiplication program (p. 106; 111). Bolton seems to have recommended a complete shift in the program from LH11 to SR52 and from synthetics to composites. Since then, no synthetics have been released.

Until recently, the International Maize and Wheat Improvement Center (CIMMYT) has exclusively developed OPVs. CIMMYT's involvement with Malawi's maize breeding program began in the 1970s with a visit from Ernie Sprague, Head of the Maize Program in Mexico, the transfer of subtropical and lowland tropical OPV material, and some short-term training at CIMMYT headquarters in Mexico. By that time, however, the Malawi program was beginning to deemphasize composite development and was keen on releasing their own hybrids to replace SR52. CIMMYT posted a maize breeder in Nairobi during the 1980s, but not until the Harare office and midaltitude station were established in 1985 did the CIMMYT maize breeders become actively involved in the discussion of breeding strategies and in germplasm development for both OPVs and hybrids in Malawi. In fact, until the late 1980s when the work of the Harare breeders began to produce midaltitude and locally adapted materials, much of CIMMYT's germplasm was best suited for the lowland tropics and they had less to offer in terms of midaltitude (subtropical) material. A number of CIMMYT lines have nevertheless been used in Malawi's program and, since the late 1980s, Malawi has been considered a priority for the CIMMYT Eastern and Southern Africa program.[33]

Even when the Malawi program produced denty hybrids intended for cultivation as a cash crop, semiflint OPVs continued to be produced and were viewed as the appropriate seed for small farmers. The problem is that the synthetic lines were abandoned and the adoption of composites has dwindled over time. UCA lodged easily and, although its shortcomings were eliminated with the release of CCC and CCD, there has since been very little attempt to educate farmers about OPVs or to promote and diffuse them as an alternative to hybrids. In the CIMMYT/MOA survey, farmers recalled UCA, few had heard of CCC or CCD, and even fewer knew the difference between a hybrid and a composite.[34] Little composite seed is produced and little of it is demanded, but it is not in any case accurate to say that farmers have rejected the new composites.

The intensity of research interest in the flint trait has generally accompanied shifts in research focus between OPVs and hybrids because commercial hybrids were denty. However, a number of factors converged in support of the infusion of flintiness into hybrid development in the late 1980s. These factors included a strengthening of the Maize Commodity Team; assistance from CIMMYT's regional breeding program; and changes in the National Seed Company of Malawi's (NSCM) portfolio which accompanied the involvement of Cargill's breeders. Breeding for flintiness has always been associated with OPVs, and it was in large part the financial pressure exerted by donors that resulted in the pursuit of flinty hybrids.

Length of Growing Season

Commercial hybrid seed in Southern Africa has a development cycle of more than 150 days over much of the midaltitude range in which it is grown (Low and Waddington, 1989). Of the varieties released by the Malawi program, MH16 and MH18 have 125- to 130-day cycles and CCD has a 120-day cycle at approximately 1000 meters above sea level. Among the hybrids, only NSCM41 is 120-day. In most cases, however, local maize matures more slowly than the improved varieties—a characteristic that has added to the attraction of hybrids.

The Malawi maize breeding program has, over the years, released a few synthetics, composites, or hybrids with shorter growing seasons. These materials, produced primarily for the lakeshore or lower-elevation environments, have greater probabilities of drought escape. Until recently, however, the maize program has not consciously addressed drought tolerance or the related issue of heat stress as a breeding objective. Now, a low-altitude hybrid program (under W.G. Nhlane) and a low-altitude OPV program (under E.M. Sibale) are operated from Chitedze, with materials tested at Chitala and other sites in the lakeshore region and Shire Valley. Concentration on early maturity and heat and drought resistance could increase adoption rates in some less favorable environments of Malawi. Early maturity and drought tolerance could also provide more options for late planting in more favorable environments, a fact

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[33]Streak-resistant material contributed by IITA (another of the CGIAR institutions) is likely to become increasingly important in the future.

[34]For example, researchers recommend that hybrid seed be bought each year while composites can be grown for 3 years between seed purchases.

that is not widely recognized. Drought and heat tolerance are areas in which collaboration with CIMMYT might prove fruitful.

Soil Fertility

From the colonial period to the present, the major nonvarietal research issue in Malawi has probably been soil fertility or, more broadly, soil conservation. Given the pressure on land and the predominance of maize in the cropping system, it is evident that much of the arable land in Malawi is continuously cropped to maize, a crop that extracts large amounts of nutrients from the soil.

In general, assessing the impact of crop management (e.g., nonbreeding) research is more difficult than measuring the impact of varietal development. The yield figures cited in this report appear to justify the assumption that yields of unfertilized local maize have been declining over time. Application of inorganic fertilizer has therefore contributed to maize productivity despite nutrient/output price ratios that are quite high by world standards. This application has been encouraged both by past research results and by extension efforts.

The continuing dominance of maize in the farming system and high costs of imported fertilizer has also spawned additional research efforts. One line of attack is agroforestry, although there are considerable technical and managerial issues that must be resolved before this can be recommended as a large-scale solution. Other research seeks to improve the efficiency of conventional fertilizers. To the extent that improved maize varieties perform well under relatively low fertility conditions, and to the extent that improved maize yields release land for other crops, breeding research can also contribute to alleviating soil fertility problems.

Human Resources, the Organization of Research, and Research Capacity

Discontinuities

A major problem with the evolution of the maize program was that instead of cumulating a depth of expertise and a range of germplasm, the program was beset by discontinuities and shifts in staff. Initially, the dependence on expatriate staff on fixed-term contracts and later, the lacunae caused by the departure of key Malawians for long-term training contributed to the scantiness of human resources. Kydd characterizes the late colonial period with Ellis (1953 to the late 1950s), the early 1970s (Bolton's period), and the late 1980s as peak productive periods in the maize breeding program. The first slowdown of activities during the 1960s is easily attributable to the change in administration. The second, in the late 1970s, Kydd blames on (1) donor misconception, based on overly optimistic reports from parts of Lilongwe Agricultural Development Division, that adoption rates were high enough and Malawi had no "maize problem"; (2) World Bank preoccupation with the then-popular notion of the Integrated Rural Development Project over technology generation; and (3) misguided allocation of national research funds toward less important crops such as rice and cotton.

Institution Building

On the other hand, the late 1970s and early 1980s were a period during which there were changes in the organization of maize research, adaptive research became a formal part of the research system, and the training of numbers of researchers culminated in improved maize research capacity. In-service training was a large part of CIMMYT's involvement with DAR and, at one time or another, most of DAR's maize scientists attended short-courses at CIMMYT headquarters. Although often criticized, the University of Florida project[35] and the opportunities it provided were instrumental in changing the organization of research and in long-term training of scientists.

Though a small part of the project, the farming systems research (FSR) component had activities that were designed to improve research and extension communication and eventually led to the establishment of the Adaptive Research Teams (ARTS) in the Agricultural Development Divisions. At that time, the Department of Agricultural Research was reorganized into the interdisciplinary commodity team structure it has today. Another structural change encouraged by the project was to set up a series of discussions in which researchers exchanged results. However, the project took from one-third to one-half of the experienced researchers out of Malawi for training—at only one institution.

In coordination with the economist from CIMMYT, the social scientist on the team succeeded in introducing a farming systems perspective into crops research. Diagnostic surveys conducted at that time resulted in two notions that would later become more widely accepted. One notion was the rediscovery of the cultural importance of local maize varieties and the fact that, for subsistence farmers, yield from the mortar is a better indicator of the economic value of a variety than grain yield. This rediscovery is today reflected in the maize breeders' continued work with local maize collections. Research findings also suggested that fertilizer use on local maize should be promoted to reduce the area required for staple food production and release area for cash crop and hybrid maize cultivation. Considered as an undesirable alternative strategy at the time, fertilizer use is now recommended on local maize, even though hybrid maize is no longer viewed solely as a cash crop.

Much of CIMMYT's involvement with Malawi's research program during the 1980s was also related to the establishment of the ARTs and training of adaptive research personnel by three CIMMYT Regional Economists. Their approach emphasized the need for social scientists and on-farm research with a systems perspective. Adaptive Research now has one of the most poorly staffed teams and one of the highest attrition rates of the research units, but certain key concepts such as interdisciplinary commodity teams, the importance of considering a wider range of breeding criteria, and a continued emphasis on developing technology for local maize have probably resulted from the work of the 1980s.

From the beginning of Malawi's maize breeding program until 1977 and intermittently until 1987, the post of Maize Breeder was held by a succession of expatriates on fixed-term contracts. In all other years, the same Malawians have held positions as breeders—B.T. Zambezi, who has been with the program for over 20 years and is now the only PhD on the staff, and W.G. Nhlane and E.M. Sibale, who have worked with the program for about 15 years and are now completing their PhDs. Aside from these individuals, technicians are an often overlooked but important source of continuity in the program. For example, when the three Malawian breeders were abroad on training during the 1980s, the technicians maintained the lines for MH15 and MH16, CCC and CCD, which were subsequently released when the breeders returned. With respect to technical assistance, involvement with CIMMYT has also been a source of continuity in the program.

Based on a comparison from 1985/86 relative to other commodity teams, the Maize Commodity Team now ranks high in terms of years of experience per researcher, level of education, percent of researchers receiving promotions, and low attrition rates. Promotions have largely been among professional rather than technical staff. What these indicators suggest is

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[35]The University of Florida project was the first of a series of USAID projects aimed at strengthening agricultural research.

that the level of commitment in terms of credentials, length of stay, incentives and professional satisfaction is greater than it is among many of the other teams. Behind these figures are, compared to previous decades, the strong financial commitment of the GOM, the World Bank, and the Rockefeller Foundation to maize research in Malawi.

Another recent organizational change on the part of the Maize Commodity Team was the preparation of the 1989 *Maize Action Plan*, the first of its type among the commodity teams. The development of a flint hybrid was designated as a priority concern and, with the greater involvement of CIMMYT in breeding strategies during the last few years, CIMMYT personnel assisted in drafting the plan.

Among other factors inhibiting the progress of agricultural research systems in sub-Saharan Africa, Lipton (1988) has cited the lack of "critical mass of scientists" and "inadequate integration of economics and social analysis into agricultural research." Although these criticisms probably still hold true in Malawi, the institution-building efforts of the 1980s have begun to address these issues.

Input Distribution, Marketing, and Price Policies

Seed Supply

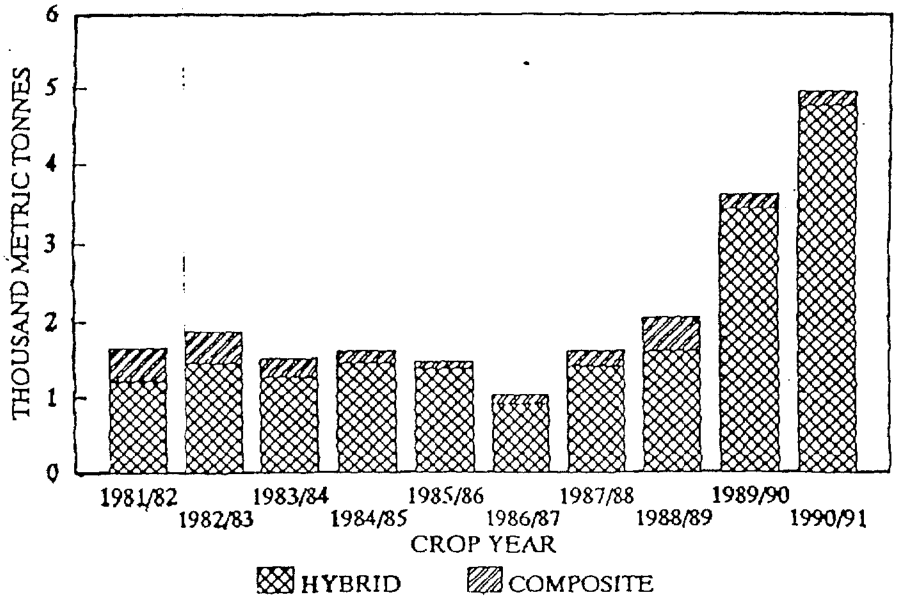
At various points in time, seed quality, multiplication, and distribution problems have interacted with other factors to inhibit farmer adoption of varietal releases. For example, Quinten and Sterkenburg (1975) reported that although LH11 was a semiflint variety, it was not very popular—partly because of a seed supply difficulty. The germination quality of one of the first large-scale seed crops was poor which influenced the demand in later years, although the quality improved. In 1971–72, the seed was supplied to the local markets very late in the season and farmers had already decided to grow local varieties.

ADMARC and the Ministry of Agriculture were responsible for seed production until the late 1970s when the National Seed Company of Malawi (NSCM) was established. For the most part, seed distribution in the early years was confined to Lilongwe Land Development Programme (LLDP). In the mid-1980s, NSCM obtained government clearance to pay royalties to Ciba-Geigy for the F1 material to produce NSCM41, a denty hybrid that is genetically similar to R201 (Zimbabwe) and processes relatively well. What is not clear is the role of ADMARC's financial problems in the mid-1980s slump in seed sales, or to what extent low seed sales figures represented a production, distribution, or demand question. The rapid increase in sales over the past few seasons suggests a latent excess demand for hybrid seed—so that in some years seed supply may have actually been the limiting factor.

Breeding and seed production under rainfed conditions affect the speed of varietal releases and seed supply. In Malawi, sufficient irrigated land to complete two breeding cycles per year could have increased the flow of improved materials through the research system, assuming adequate staff and other resources. Without irrigation, when farmers are contracted for the final stage of seed production, certain types of hybrids that require synchronization (MH15) are more difficult to produce. In a poor growing season such as the 1991/92 season, substantial amounts of seed stock can be lost.

The costs of seed production also vary by hybrid type. A single cross hybrid such as MH12 is more expensive to produce than a three-way cross like NSCM41. In general, the higher the yield potential the more expensive the seed, so that, with a fixed budget, the varieties that exhibit the greatest yield differential with respect to local maize can only be produced in smaller quantities. Nonconventional top-cross hybrids (MH17 and MH18) are generally less expensive to produce than conventional hybrids, but are produced at the expense of greater

Figure 6.1. ADMARC Sales of Improved Maize Seed 1981/82–1989/90 and Preliminary 1990/91



yield variability and possibly lower average yields in farmers' fields. Over three years of breeders' trials, however, MH17 and MH18 yield did not differ statistically from those of MH12 and MH16, respectively. In Malawi, where contract growers are often estates, growing maize seed must be at least as profitable as producing alternative crops—such as tobacco.

The varietal composition of seed supply has not always suited farmer preferences because little was known about effective farmer demand. In the CIMMYT/MOA survey, farmers often reported that they had no choice of hybrid varieties from year to year—they sowed what was in sheds or what was provided by the clubs. The simplest criterion for varietal mix is unsold seed stocks, but determining the "correct" varietal mix when farmer demand is changing takes time.

Most observers believe that NSCM, now majority-owned by Cargill,[36] has adopted a more aggressive approach to seed production, seed procurement from abroad, and seed sales during the past few seasons. Figure 6.1 shows the marked increase in sales of composite and hybrid seed since the 1986/87 low.

[36]Cargill, the largest privately-held company in the world and one of the world's largest grain traders, also has substantial interests in seed production worldwide.

Seed Diffusion

The Government of Malawi has promoted hybrid seed as part of a seed-fertilizer package that is extended through formal credit clubs with subsidized credit and stringent repayment requirements. In the early 1980s, credit club members composed only an estimated 10 to 15 percent of the farm population (Kydd, 1989), although the percentage has grown considerably and is greater in the high-potential maize production zones. In the survey zones, for example, from a quarter to a third of farm operators were club members in the second survey season (CIMMYT/MOA data). Although credit club membership has facilitated adoption by relieving seasonal cash flow problems, nonmembers also adopt hybrid seed and fertilizer through careful organization of the cash resources they obtain from sales of alternative crops or off-farm wage income. Credit club membership has generally been associated with greater chances of personal attention from extension workers.

In the past, the packages that were distributed to club members were of a fixed size and composition. Credit club members sowed the seed variety that was provided in the package and applied the type of fertilizer they received on one-acre (0.4-hectare) plots. This diffusion method created a lumpiness in land allocation and curtailed farmers' experimentation and their ability to adapt the technology to their own conditions. Currently, in recognition of the need to address a wider range of technological options, the government has begun to provide packages of varying size and composition. Although hybrid seed was always promoted with fertilizer, recent research results indicate that, in some zones, hybrid varieties can yield as well or better than local varieties with no fertilizer. Of the two input costs, fertilizer is undoubtedly the more limiting. Malawi is a landlocked country and fertilizer imports are transported overland at high cost. In recent years as part of donors' structural adjustment program, fertilizer subsidies were gradually reduced at the same time that internal strife in Mozambique blocked Malawi's cheapest external transport route. Unwilling to pass all the cost burden to farmers, the government eventually abandoned the subsidy removal.

Recent research has demonstrated that Malawi hybrids perform well even under relatively low-input conditions and that for some farmers, adopting hybrids without fertilizer may be economical (Jones and Heisey, 1993). If farmers are convinced they must grow hybrid maize with fertilizer, or if they are only permitted to purchase seed with fertilizer, their inability to pay for fertilizer inhibits their seed choice. On the other hand, the percentage of farmers who use fertilizer on local maize is higher than the percentage of credit recipients. Credit recipients are a subset of fertilizer users. When farmers can afford fertilizer, the incremental cost of seed is slight—if that seed can be found in local markets.

Marketing System[37]

Irregular marketing conditions have also impeded the purchase of both seed and fertilizer by noncredit club members. Initially, fertilizer and seed in rural areas were sold at official ADMARC outlets. These markets were not evenly dispersed in all village areas, nor did they always stock inputs. When ADMARC operations began to incur heavy financial losses, many of these input sheds were closed. By contrast, inputs were delivered free to credit club members. The dependence on credit as a diffusion mechanism undoubtedly slowed the development of private markets for inputs. In isolated areas outside the credit system, seed and fertilizer are still not easily found.

Official maize output prices are announced seasonally, and are panterritorial, uniform over the harvest season, and equal for all maize varieties. Although few price series exist, with market liberalization there is increasing evidence of price differentials between hybrid and local varieties and intraseason price variation on local markets. The difference in the way farm households value local and denty hybrid maize may appear in price differentials in local markets but is suppressed in the official price. Because of consumer preferences for local maize and the credit repayment system, a higher proportion of hybrid maize circulates in official markets. Local markets in many rural areas are also likely to be thin, especially in certain seasons.

When the official prices capture little economic information, and private markets have only begun to operate, either observing true valuations for maize or studying farmers' re-

[37]Appendix B contains more details on the history of maize marketing.

sponses to these valuations is difficult. Econometric analysis of the CIMMYT/MOA data nevertheless shows that although the effects of conventional price ratios and relative profitability variables on hybrid maize adoption are weak, the same measures do significantly affect the level of nitrogen applied by farmers to local maize. In hybrid maize adoption, other factors such as the diffusion method (credit), consumer preferences (subsistence requirements), and learning have probably played a larger role because of controlled prices. A higher proportion of farmers purchase fertilizer with cash for their local maize and, when possible, prefer to sell their local varieties on local markets where prices are generally higher and more variable.

Promotional Efforts and Farmer Learning

Perhaps as a result of early farmer responses to denty varietal releases, hybrids have been generally promoted as a cash crop. Over time, as suggested above, some changes in consumption patterns (if not consumption preferences) have undoubtedly occurred and even denty hybrids have played a role in household food security. Especially in the Blantyre zone and some parts of the Kasungu zone, CIMMYT/MOA survey farmers often ranked earlier maturity above yield as an advantageous characteristic of hybrid varieties. Now, especially with the flinty hybrid releases, the importance of producing a more flexible promotional effort that emphasizes food security as well as potential cash income should attract the interest of a broader base of farmers.

Focussing on profitability of hybrid maize, combined with limiting its diffusion to credit clubs and emphasizing the importance of following rigid recommendations, may have limited the receptivity of large subsets of farmers, and even those capable of self-financing. Culturally, the term "local" is usually associated with certain traits, such as flintiness and whiteness. *Chimanga cha makolo* means maize of the ancestors, or a gift conferred by families through generations. Some researchers have suggested that "local" is not so much a term referring to grain characteristics, and that *cha makolo* does not literally describe the origin of the seed, but that both are terms signifying the seed's institutional affiliation.[38] In some sense, "local" maize is the maize of rural people, or of farmers. By contrast, released varieties are brought to the locality from outside (formal) institutions, whether these are national or international. Occasionally, survey farmers called hybrids *chimanga cha boma*, which means, in common parlance, "maize of the government."[39] Since hybrid seed is either purchased or provided on credit which is repaid by selling at least some of the harvest, many farmers probably did not perceive that the seed was their own or was produced with their interests in mind.

Extension messages with single themes were undoubtedly useful in the early introductions, but over time may have discouraged farmer experimentation that might have resulted in adoption and greater farmer benefits.[40] For ex-

[38]Based on his farming systems research work during the 1980s, Hansen (1986) has described local maize as a folk category with two defining characteristics: (1) flintiness; and (2) the seed did not come directly from the government but was retained from the previous harvest or purchased on the local market. At the same time, Hansen discovered a "localization" process by which governmental origins were forgotten in areas where seed exchange and introduction programs had been active. In those areas, such as Lilongwe ADD, the local category also included the names of old released material that had been recycled. In the CIMMYT/MOA survey the same phenomena were found in different localities.

[39]The origin of *boma* is British Overseas Military Administration, designating administrative bases in colonial territories.

[40]Writing about parts of Lilongwe ADD in 1987, Chipande wrote that the least endowed farm households (female-headed) did not even bother to ask for

ample, the emphasis on pure stand cultivation for hybrids is now relaxing as field workers observe that farmers in some zones have reasons for intercropping maize, whether it is a hybrid or a local variety. Smallholders who both consume and market crops have diverse objectives, and producing hybrid maize under conditions that may not be agronomically optimal may nevertheless be economically optimal for them.

On the other hand, continual exposure to other farmers who grow hybrid maize and, more recently, to radio messages that exhort farmers to grow hybrids has probably contributed to the upsurge in adoption, particularly in the Southern Region. Analysis of the CIMMYT/MOA data confirms that farmer experience with hybrid varieties increases the probability of sowing hybrids in successive years. Once a "critical mass" of hybrid maize growers accumulates in a given locality, the general level of knowledge about the varieties also increases. Those with limited levels of working capital are more able to experiment "passively" (by observation) than "actively" (by paying the costs of gaining information from their own fields). Farmers who observe success and who have the resources to adopt can then adopt at faster rates and there is an increase in the slope of the aggregate diffusion curve, as is evident in the figures from the Southern Region.

Farming Systems

Although maize dominates the farming systems of all of the major maize-producing zones of Malawi, essential agroeconomic differences exist between zones that probably determine differential adoption ceilings even when other factors such as consumption preferences and diffusion mechanisms are similar. For example, in parts of the Southern Region the importance of off-farm income and relative wages in labor allocation decisions implies that hybrid maize will be adopted only when labor returns are greater in hybrid maize production than in alternative income-earning activities. In Kasungu and parts of Lilongwe ADDs, by contrast, adoption rates and area sown to hybrid maize can be expected to fluctuate in response to competitive conditions with alternative and more remunerative cash crops. The higher proportion of full-time farmers on the Central Lilongwe and Kasungu plains and their relatively greater yield potential because of soils and rotations suggests that the ceiling adoption rates will be higher than in the South. In Rumphi and Mzimba Districts of the Northern Region, the central importance of maize in the cropping system as both a food and a cash crop suggests that adoption ceilings will be highest and cumulative levels most stable in that zone, other factors held constant.

credit because of their assessment of their land and labor constraints--"they were afraid." In the CIMMYT/MOA survey, some households expressed the same sentiments with respect to growing fertilized hybrid maize on credit.

7. Conclusions

The evidence collected in this paper suggests the following conclusions regarding the history and effectiveness of the national maize breeding program in Malawi:

(1) Malawi's maize program, as compared to other conventional breeding programs in the region and elsewhere, did incorporate socioeconomic considerations into its breeding objectives. Since its inception the program has addressed the consumption preferences of small farmers which are related to the processing and storing characteristics of flinty varieties, by breeding semi-flint hybrids or semi-flint open-pollinated varieties (OPVs).

(2) Until the recent development of the two semi-flint hybrids MH17 and MH18, the major underlying constraint on the speed of release of flinty varieties had been lack of suitable flint germplasm. Inbred lines developed from local flinty materials are too tall and have too long a growing season. Exotic flint germplasm was difficult to locate because the focus of most maize breeding efforts in other parts of the world had been denty varieties.

(3) Item (2), when combined with the discontinuities in senior staffing and financial support through the 1970s, led to counterproductive conflicts in breeding objectives and swings in emphasis among synthetics, composites and hybrids. At critical points in the early years of the program, a weak decision-making structure and the need for more trained Malawians in decision-making positions severely curtailed germplasm development.

(4) Flintiness is only one of many breeding factors and socioeconomic factors that have affected the impact of varietal innovations on adoption rates.

Lessons Learned

Specifically, the above conclusions are associated with the following "lessons" for breeding programs with that operate in similar conditions:

- The flint maize preferences of farmers led to complexity in breeding objectives. The major constraint to breeding popular flint hybrid varieties was not that breeders ignored the significance of flint character, but that there was limited local and exotic flint germplasm that was also high-yielding, short in stature, and shorter in growing season. Each of Malawi's major breeders, in one way or another addressed a concern for "yield from the mortar," either by attempting to breed a semi-flint hybrid or a semi-flint OPV.
- In the early (post-independence) years of the program when varieties were distributed primarily in the Lilongwe area, the effective demand for hybrid seed was found among commercial farmers whose foremost concerns were harvest yield and production for sale. To meet the perceived demands of two groups of clients—commercial farmers and subsistence farmers—the program pursued the dualistic strategy of importing the high-yielding, denty SR52 from Zimbabwe

for cash crop production and developing flinty OPVs for smallholders. The need to replace hybrid seed imports because of high costs led them to the development of denty indigenous hybrids. Breeding denty (rather than flinty) hybrids was expedient and was a first step in indigenous varietal diversification.

- Although development and importation of denty hybrids and their promotion as a cash crop effectively reduced the ceiling adoption rate by focusing on larger or more well-endowed producers, the breeding program always worked with OPV alternatives designed to meet the maize subsistence needs of smallholders. Two problems affected the progress of the OPV program: (1) discontinuity in breeders; and (2) a limited range of high-yielding, mid-altitude material suitable for developing Malawian lines. An example of (1) is the deterioration of the synthetic lines bred by Ellis and their subsequent rejection by Bolton. An example of (2) is that although CIMMYT breeders sent mid-altitude (at the time, "sub-tropical") materials to Malawi in the 1970s and 1980s, their more attractive materials were not developed until the mid-altitude station was established in Harare in 1985.
- For OPVs to have been successful (in Malawi they have been popular to a moderate extent and over brief periods in selected localities), they needed yield, disease-resistance, drought-resistance or early maturity, in addition to flintiness. The history of OPV successes shows that both OPVs as well as hybrids need to be "spectacular." OPVs can be high-yielding, however, and the argument that only hybrids will work in Malawi is unfounded. In any case, OPV development is of continued importance in breeding lines for kernel texture and other desirable characteristics to use in the hybrid program, and in maintaining a varietal portfolio.
- For either hybrids or OPVs to have been adopted at a steadier and faster rate would have required more of a commitment to seed production and distribution. Although it may be true that the involvement of a private seed company can provide a key impetus at certain stages of the breeding process, in most success stories the role of private companies in seed distribution has been even greater than their role in breeding. On the other hand, private seed companies are not usually as interested in OPVs. To guarantee that OPVs are given a chance with farmers, a conscious public sector effort is needed to distribute the seed widely and to educate farmers about the relative advantages and disadvantages associated with OPVs and hybrids.
- Flintiness is not the only issue affecting research impact. The diffusion mechanism (limited to credit clubs and packages of fixed composition and size), the varietal composition of seed supply, the economic risk of taking fertilizer and seed on credit (or of allocating land away from subsistence production), and farmer learning (which takes time and accumulation in a locality) influence farmer adoption decisions.
- Flintiness is also not the only important trait that affects varietal adoption. Other important breeding issues involve, for example, plant stature and length of growing season.
- Even the discontinuities in funding, staffing, and breeding objectives that were related to the turnover of expatriate breeders and ebb and flow of financial support would not have jeopardized the program if there had been more senior Malawian breeders before the mid-1970s. Since then, although the three Malawian senior breeders have taken over decision-making responsibility, overseas training has caused some disruptions. The program will soon have three PhD-trained breeders with lengthy experience—but there is no "younger generation"

of breeders in line to follow them. The sheer number, and not the quality of the personnel has been a problem. At this critical juncture in the breeding program when the impact of recent varietal releases is becoming apparent, the need for a new generation of breeders to sustain varietal development cannot be overstated. The experience of the maize program has shown that the next generation of breeders is usually best drawn from promotions within the system, from technical to professional officer.

- The need for socioeconomic contributions to the maize program has been recognized since the early 1980s, but the capacity for socioeconomic research has not been successfully institutionalized.
- In a nation where maize is of such critical socioeconomic importance, the issue is not whether maize research should be funded but how to improve the efficiency of maize research through addressing some of the above concerns. As demonstrated clearly in the Malawi case, the impact of maize research should also be viewed in terms of the welfare loss associated with no maize research.

Windows of Creativity

The recent release of MH17 and MH18 by Malawi's national research team is an example of how the scientific creativity of several individuals has coincided with certain conditions to generate the potential for rapid technological change. The new hybrids are the first semi-flints developed since the colonial period and have the processing and storage traits valued by small farmers as well as the yields that compare to the denty hybrids previously grown as cash crops (Smale et al., 1993). The speed of their release (only three years after the initiation of the semi-flint hybrid program in 1987) can be attributed in part to the convergence of factors, including (1) the idea of breeding a top-cross rather than a conventional hybrid; (2) the comfortable working relationship with CIMMYT's regional breeders that enabled the Malawi team to identify appropriate parent material in Population 32; and, most importantly, (3) the years of development and maintenance of parent lines by technicians and breeders as they gradually accumulated germplasm and experience. The work of the three senior breeders, B.T. Zambezi, E.M. Sibale, and G. Nhlane, was publicly recognized for the first time when they received the MASTA (Malawi Award for Scientific and Technical Achievement) from the Government of Malawi for the new hybrids. Additional donor support to the maize program may have facilitated the progress of the maize team by enabling its members to obtain advanced degrees and pursue their research with fewer operational constraints. However, without the dedication of the breeders to their work during more difficult years, the breakthrough would not have occurred so rapidly. Concurrently, adoption rates for denty hybrids have been rising as weather conditions underscore the yield advantages of the shorter-season hybrids over farmers' varieties, and as the quantities of seed produced and marketed have increased. The scientific breakthrough, combined with the growing receptivity of farmers to hybrids and gradual improvement in seed production and marketing have created a situation that is ripe for major technological change in Malawi's farming communities.

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Appendix A

Principal Data Sources

A. CIMMYT/MOA Maize Varietal and Technology Adoption Survey

The data collection effort was funded by the International Maize and Wheat Improvement Center (CIMMYT) and implemented with the support of the Department of Agricultural Research and the Planning Division, Ministry of Agriculture. Entitled the CIMMYT/MOA Maize Technology and Varietal Adoption Survey (MVTS), the field research was conducted in 3 of the 5 major maize-producing Agricultural Development Divisions (ADDs) of Malawi, to a subset of households (420) participating in the Annual Survey of Agriculture (ASA) during two cropping seasons.

Following the recommendations of the Department of Agricultural Research, segments of Blantyre, Kasungu, and Mzuzu ADDs were chosen as representative of contrasting agro-ecological and economic characteristics found among major maize-producing regions. Variables hypothesized to affect maize technology adoption differ sharply between the zones, and the 3 zones constitute the strata for the MVTS.

Within each ADD, households were selected from the multi-stage, stratified cluster sampling frame designed by the National Statistical Office for the ASA. The survey households form a statistical sample drawn with equal probability of selection within each of the 3 zones and varying probability of selection between zones. Statistical statements generated from the data are broadly representative of farm households located in the major maize-producing, higher potential adoption areas of Malawi.

The MVTS was designed as a module attached to the ASA and covering a subset of households included in the 1989/90 national sampling frame. In consultation with Ministry of Agriculture officials, this design was chosen because the ASA households are selected with probability sampling procedures, the ASA questionnaires elicit extensive agronomic data related to maize technology, and the ASA enumerators are fully-trained, professional field investigators that reside in survey villages. The MVTS included questions designed to provide more detailed varietal information, information on farmer perceptions and experience with varieties, and supplementary wage and price information used in valuing costs of production, output, and household income. The variables measured in this report therefore represent a combination of those assembled from the routine ASA data, additional variables collected in the MVTS, and variables composed by transforming and combining the complementary data sets.

B. Food Security and Nutrition Monitoring Project

The Food Security and Nutritional Monitoring project, implemented in the Ministry of Agriculture as a collaborative effort between the Planning Division and Food and Nutrition Unit, has as its objective to provide periodic information that can be used to monitor the household food security position and nutritional status of the population in all 8 Agricultural Development Divisions. The sample frame for the FSNM survey is also the ASA frame, but 10 out of the 20 households in each Enumeration Area (EA) are interviewed for a total of about 2500 households. The questionnaire consists of "Food Security," "Expenditure," and "Nutrition" modules.

C. Annual Survey of Agriculture

Originally designed for the 1980/81 National Sample Survey of Agriculture, the ASA sampling frame is a stratified cluster design in which the nation's area is divided into approximately 200 agroecological strata, and each stratum (primary sampling unit) is composed of a varying number of EAs or sampling clusters composed of roughly equal populations. The strata are contained within 8 Agricultural Development Divisions (ADDs), which are administrative and development units responsible for implementing and evaluating the Rural Development Projects (RDPs) in their geographical zone. Evaluation Units in the ADDs implement the ASA, as well as other smaller-scale surveys requested by the Ministry of Agriculture.

Since 1985/86, Evaluation Officers for the ASA have implemented a rotating EA sample designed in that year by the National Statistical Office. In each EA the enumerator responsible for collecting the ASA data lists all households at the beginning of the cropping season (200-300), and from the list frame a systematic random sample of 20 households is drawn. Selection of strata with probability proportionate to size of population, and subsampling of clusters of about equal size ensures that the overall probability of including a household in the sample is the same for all households in the population. More densely populated ADDs and strata have a larger number of EAs, sample EAs, and sample households. Changes in population have eroded the self-weighting design over time with subsequent difficulties in developing weighting schemes for computations of aggregates, but the 1989/90 sample was based on a revised stratification and more recent 1987 Population Census figures.

The ASA questionnaires consist of 4 modules, or schedules. The household form contains questions on the demographic composition of the household, hours and type of off-farm employment, hours and type of hired farm labor, the value of remittances, and quantity of livestock owned by the household. Data are gathered in 4 visits covering the calendar year. The garden worksheet is used for measurement of all fields and plots operated by the household. The plot survey records basic agronomic information for each plot cultivated by the household as well as objective yield measurements from yield subplots, and is administered intermittently throughout the cropping season. The operator form consists of questions about use of credit and extension services by the household, and is addressed to the operator(s) following harvest.

Appendis B

Economic and Policy Context of Smallholder Maize Production

A. The Pre-Independence Period

Malawi's pre-independence economy has been characterized as consisting of plantation, smallholder, and labor reserve sub-economies (Kydd and Christiansen, 1982). Reliant on world market opportunities, the plantation sub-economy was founded successively on coffee, cotton, tobacco, and tea. Encouraged by the colonial administration through land alienation, hut taxes, and tenancy arrangements, its socio-economic impact was heaviest in the Southern Region and in some parts of Central Region.[1] The labor reserve economy supplied labor for the mines and European commercial agriculture in South Africa and Rhodesia through the early 1970s. Both the colonial administration and the estate economy created markets for maize and other smallholder foodcrops and Kydd and Christiansen assert that, because of the weakness of the estate economy, smallholder cash crop production was officially supported from the 1920s to the 1960s.

An overt colonial policy of promoting smallholder cash crop production is also documented by Kettlewell (1965). Before World War I contributions of the colonial administration consisted of limited specialist advice for the plantation crops. After World War I, for "agricultural development" purposes, the administration expanded field services to smallholder production of tobacco, cotton, and rice. The Nyasaland administration appears to have devoted few resources to general husbandry until the Great Famine of 1948-49. Subsequently, various soil conservation methods, early preparation and planting, and improved processing and preparation of crops for market were recommended for small-scale cultivators. Kettlewell describes the overall policy at independence as the pursuit of "gradual improvement for the mass of cultivators" while "concentrating on the most progressive individuals" (p.243). Of relevance to current efforts to promote fertilized hybrid maize is the fact that subsidized fertilizer was available to at least a subset of farmers in Nyasaland from 1952 onwards.[2]

Kettlewell refers particularly to maize when discussing the changes in pricing policy that were instituted after the Great Famine. In the following season the Maize Control Board established formal control over maize marketing and set a guaranteed price at twice the previous level. In 1952, the Maize Control Board was reconstituted as the Produce Marketing Board and was authorized to purchase other crops and export surpluses to Europe. The new policy appears to have increased the importance of maize as a cash crop, especially in the Central Region. Maize acreage increased and the marketed response for maize was so great that maize was eventually exported at unremunerative world prices. From 1957 the administration pursued a

[1]Combined with high population densities, land alienation for estate production restricted land available for smallholder cultivation. A village headman in Chiradzulu is reported to have said in 1937: "As I look to Crown Land, I see no land remaining where so many of my people could go. I look in the air, I see I cannot fly there, then I come to the point that I say what is the use of living." (Public Record Office, London. CO 525/165. Minutes of the Chiradzulu District Native Association.)

[2]In the CIMMYT/MOA survey, a number of the older farmers claimed that they first used fertilizer in the pre-independence period.

policy of minimum uniform pre-planting prices tied to world market prices, and price stabilization through utilization of buffer stocks (Kandoole et al., 1988). The objective was to restrict maize production to local needs plus a famine reserve, encouraging maize as a cash crop only in those areas most suitable for its production. The marketed surplus nevertheless remained excessive. The administration responded by relaxing the monopoly of the marketing board and reduced its role to that of a procurement agent for government departments, commercial orders, industrial and urban markets, and a strategic reserve. Maize was no longer produced for export, although the famine reserve could be exported each year after the new harvest was assured (Kettlewell, 1963; Kandoole et al., 1988; Brown, 1963).

B. The 1970s: Emphasis on Estate Agriculture

As in other post-independence African economies, the major features of Malawi's pricing system during the 1970s included government administration of both input-output and producer-consumer price ratios through a marketing board with a quasilegal monopsony and monopoly over sales of agricultural inputs and commodities. The policy concerns of the GOM included regulating maize prices so that they were high enough to stimulate producers but low enough for urban consumers, taxing export crops for government revenues, subsidizing imports like fertilizer and fuel and, reflecting equity considerations, establishing a pan-territorial pricing regime (Kirchner et al., 1985).

Aggregate figures show high growth rates for estate production during the 1970s (Lele, 1989a; Kydd and Christiansen, 1982; Humphrey, 1975; Thomas, 1975). The estate share of exports grew from 32 percent in 1967 to 65 percent in 1979 and 80 percent in 1981-82 (Kandoole et al., 1988). The nation's impressive performance in terms of GDP growth was offset by evidence of distributional problems and declining real income of rural households (Kydd and Christiansen, 1982; Pryor, 1990). Malawi's agricultural economy during the 1970s has been termed "dualistic," with the majority of farmers using low levels of technology to produce for their own domestic market and a minority using higher levels of technology to produce for the export market on estates. The prevailing view is that a conscious strategy of promoting estate production to fuel the national economy and generate much-needed revenues divided agriculture into prospering estates that were given preference in the production and sale of major export crops, and smallholders producing mostly local maize for subsistence.

Consequently, despite substantial investments in the smallholder sector by donors and the government, and Malawi's relatively superior record in the implementation of rural development projects (Lele, 1989a; Sofranko and Fliegel, 1989), marketed output of most smallholder crops and per caput maize production appear to have stagnated or declined during the 1970s (Lele, 1989b; Kydd and Christiansen, 1982.)[3] Flagging internal effective demand and widening income differentials may explain why Malawi remained a net exporter of maize over the period. Lele writes that although an estate bias may have been essential in stimulating growth with limited national resources, "the quick resumption of overall growth in Malawi may now be constrained by the extreme poverty of most of its populace" (Lele, 1989b).

One of the major policy instruments of the GOM during the 1970s was the official market-

[3]The reported figures for cash crops appear fairly inconclusive. Estimated trends for smallholder output are statistically weak. Between competing cash crops such as tobacco and groundnuts, output responses to price changes are expected to express the opposite sign and the combined results are usually ambiguous. Given population trends, per caput maize production does not appear to have kept pace with population growth in that period.

ing agency whose role expanded over time. After independence the Farmer's Marketing Board (FMB) was responsible for marketing, processing, disposing of agricultural products, subsidizing agricultural inputs, and providing adequate price stability in order to protect farmers from world price fluctuations. In 1971 the FMB became the Agricultural Development and Marketing Corporation (ADMARC). ADMARC was responsible for the buying, storing, processing and adapting for sale, distributing, insuring, advertising, and transporting all products grown for sale on customary lands. ADMARC played a stabilization role by providing storage facilities for food reserves and a food security role by transporting maize into deficit areas during the hungry season. The government reimbursed ADMARC for the difference between the prices charged to consumers and the cost recovery price, and selling prices were nearly always below cost recovery levels (Kandoole et al., 1989).

ADMARC was also viewed as contributing to the country's broader development strategy by investing the difference between the price received in the international markets for export crops and the price paid to producers, in estate expansion (Christiansen and Stackhouse, 1989). Smallholder agriculture was implicitly taxed by maintaining a gap between producer prices paid to smallholders and international prices earned for their produce (Christiansen and Southworth, 1988.).[4] Estate producers, on the other hand, sold their products by auction on the world market and remained largely untaxed (Lele, 1989b). As part of its development role ADMARC also subsidized farm inputs, including seed and fertilizer, which has been an important aspect of the MOA Rural Development Plan to encourage smallholders to increase yields and release land for cash crop cultivation without violating self-sufficiency objectives.

With the restrictions imposed on Asian traders during the 1970s and cross-border trade opportunities limited by the weak economies of neighboring countries, ADMARC increasingly dominated agricultural marketing and, in most years, effectively enjoyed monopsonistic/ monopolist status (Christiansen and Southworth, 1988.) Although African traders have been exempted from restrictions against trading produce since 1957, producer-consumer price margins have been so small that it has not been worthwhile for large traders to participate (Kandoole et al., 1988).

With maize[5], however, the volume marketed is typically only a fraction of what is produced. Unofficial markets exist alongside official markets when the announced prices do not reflect true supply and demand conditions - as in the case of maize, most of which has been marketed by small traders or through direct farmer-consumer or farmer-farmer transactions (Kandoole et al., 1988). One Agroeconomic Survey report states that although no quantitative data exists, private traders are believed to have been responsible for the bulk of inter-district and intra-district local maize trade and have played an important role in levelling deficits and surpluses (1979). The most probable result of the pricing policies followed during the 1970s was an increase in maize subsistence production relative to the production of smallholder export crops.

Kydd and Christiansen also argue that, as a consequence of low cash crop prices for smallholders during the 1970s, rates of return to labor engaged in smallholder agriculture declined.

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[4]The differential between producer and international prices for export crops consists of processing charges, marketing costs, differences expressing exchange rate disequilibrium, and the proportion held by marketing agents above these costs. Smallholders have tended to receive a relatively small proportion of the revenues obtained by ADMARC from the final sales of their output. Producer/international price ratios for tobacco, cotton, and groundnuts, for example, have been lower than similar ratios cited for Kenya and Tanzania (Lele, 1989b).

[5]Most of which was local maize or improved OPVs (synthetics and composites) in the 1970s.

The labor-intensivity of estate agriculture attracted labor from small farms. The export of labor to South Africa and Rhodesia also peaked in the early 1970s, and returning migrants were absorbed into the growing estate sector as low-paid agricultural labor rather than into smallholder agriculture. Lele (1989b) states that the shortage of land in the smallholder sector (particularly in the South), discriminatory price and land policies, and the return of migrants from Zimbabwe and South Africa have tended to increase wage employment and tenancy on the estates. Hirschmann and Vaughan (1983) cite inter-censal figures for the South and Zomba that indicate a substantial shift of male labor into full or part-year wage employment and an increase in the proportion of individuals working on their own holdings who were women.[6]

A socio-political interpretation of the effects of strategies pursued by the GOM in the 1970s is found in Hirschmann (1990). Hirschmann contends that the economic growth policies pursued by the GOM in the 1970s reduced the choices available to subsistence farmers, their autonomy, their capacity to innovate, and their nutritional security. Smallholder options were limited by policies such as ADMARC's monopoly over sales and purchase of smallholder crops, differential rights to grow and sell export crops, and the design of the credit system, combined with the reduction in the opportunities for migrant contract work. Pryor concludes that the increasing inequality of income in Malawi from 1968 to 1986 reflected growing differentials within the rural sector rather than between the urban and rural sectors. Although Malawi was one of the few African countries to consciously pursue a development strategy favoring the agricultural sector, the government provided the greatest assistance to the richest smallholders and the public and private estates. According to Pryor, "it was the wager on the strong that led to widening rural income differentiation" (p.30).

C. The 1980s: Renewed Emphasis on Smallholder Production

In 1979 Malawi's economy suffered from several "external shocks." These included the second oil price increase, decreased tobacco prices, a drought which resulted in food imports, and the war in Mozambique which led to increased input transport costs. The combined result was an increase in the current account deficit and debt service ratio, requiring the nation to produce a larger volume of exports to maintain its real income (Lele, 1989b).

In response to these problems, the structural adjustment programs conceptualized during the early 1980s and enforced by donors, emphasized the redress of account imbalances through increasing output (rather than contracting demand), reforming trade policies, liberalizing markets and reforming parastatals, and gradually moving toward border pricing. Rather than fiscal and monetary restraint, the loans extended financing to sustain both recurrent and development budgets. For example, the 1981 SAL I was designed to diversify foreign exchange sources and promote smallholder production for export. In addition to this objective, the 1983 SAL II stipulated input price changes such as phased removal of the fertilizer subsidy and shift toward high-analysis fertilizers (Sahn and Arulpragasam, 1991).[7]

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[6]Kadyampakeni offers a dissenting view by arguing that the estate and smallholder sectors are not dual but symbiotic. The estates have been the greatest employers of wage labor in Malawi, providing part-time jobs with supplementary income to smallholders. Kadyampakeni claims that disguised unemployment explains why men from the very early colonial period sought work as migrant laborers. Since 1974 when they have worked for a shorter time at closer proximity, they have been able to contribute more substantially to production and livelihood on their small holdings.

[7]Largely because of increased transport costs, the subsidy removal coincided with rapidly rising fertilizer prices. Unwilling to pass these costs on to smallholders, the GOM subsequently abandoned the program.

SAL I-III had as conditions reforms in the structure and operations of ADMARC. Financial problems resulting from excessive staffing, costly external and domestic transport and, in 1985, a liquidity crisis that resulted in ADMARC borrowing to finance crop purchases, also encouraged the government to pursue market privatization initiatives. The goal of the privatization program is for ADMARC to provide price support by acting as a buyer of last resort until the private sector assumes a greater share of marketing activity. As a first step, farmers' clubs, traders, and other private sector operators were asked to perform secondary marketing operations by offering differential prices between ADMARC's primary marketing facilities and smaller, more isolated buying points (Christiansen and Stackhouse, 1989).

The current account and budget deficits appear to have declined as a percent of GDP, but aggregate figures suggest that neither estate nor smallholder production demonstrated a supply response (Lele, 1989b). Several authors have therefore concluded that, although the policy emphasis on pricing changes have been necessary, they are not sufficient to "resuscitate smallholder production (Lele, 1989b; Sahn and Arulpragasam, 1991; Christiansen and Southworth, 1988). As pricing reforms have progressed, the importance of non-price factors in stimulating smallholder foodcrop and export production has again become evident to donors.

Sahn and Arulpragasam also question the efficacy of the pricing reforms. Output price increases for tobacco and maize were "erratic and reactive," and real prices of smallholder crops such as maize, tobacco, groundnuts, and cotton actually declined. After the drought the government raised the official maize producer price by 68 percent in 1981/82, resulting in a growing maize surplus and maize exports undertaken at a loss. Under the SALs in 1981 and 1983, donors realigned smallholder producer prices away from maize toward groundnuts, tobacco, and cotton.

Further, they argue that the degree of implicit taxation of smallholder export crops fell because of falling world commodity prices rather than higher domestic prices. Consumer prices were subsidized, but the index of the official consumer price to the official rural minimum wage fluctuated over the 1980s and was generally high, eroding the purchasing power of food-deficit rural households.

Whether open market access (market liberalization) implies greater food security has also been questioned (Sahn and Arulpragasam, 1991; Bowbrick, 1988; Lavers, 1988). Open market retail prices are consistently higher than ADMARC prices in any season, and express wide seasonal variation. Poorer consumers tend to be farther from the ADMARC distribution sites and farm households that produce a small volume of maize output relative to their needs are less likely to benefit from interseasonal price differentials. ADMARC outposts have difficulty maintaining supplies during the peak demand period that precedes the maize harvest, causing the real cost of obtaining maize to rise far higher than the nominal price. In at least some zones, private traders are an insignificant source of food supplies during the hungry season because they sell their grain immediately after purchase at harvest time (Kaluwa, 1990). From a small farmer's viewpoint, the most salient result may be that he or she can no longer sell harvested maize to meet immediate cash needs, transfer the costs of maize storage to ADMARC, and purchase the maize needed during the hungry season (Agroeconomic Survey, 1979; Bowbrick, 1988).[8] For many farm households, ADMARC essentially provided a credit facility with better terms than can be found in their villages (Lavers, 1988).

[8]In the past, farmers could sell denty hybrid output to ADMARC at harvest and purchase local maize when their local maize stocks were depleted, effectively transferring the private costs of unstorable denty hybrids to ADMARC and exchanging them for the preferred variety at a lower price than they would have to pay on local markets.

Christiansen and Stackhouse report that a variety of other administrative and logistical problems have plagued the privatization scheme. The possibility of large storage losses through improper handling of maize by traders and the question of ADMARC's inability to purchase enough maize to insure national food security have also been raised. They contend that the cost-trimming program of eliminating "redundant" markets on the criterion of volume of sales is unsound from a development perspective. A market may be low volume but service an area that is developing its potential to produce cash crops, and for which no other market catchment exists. A case in point might be some areas in the more sparsely populated Northern District where hybrid maize is a competitive cash crop for smallholders.

Most conclude that what is needed to stimulate a marketed output response by smallholders is a nexus of technical changes, adjustments in the differential rights over the production and export of tobacco, improvements in the coverage of the credit system, control over diversion of land from smallholders, integration of product and input market markets, and a period of price and supply stabilization. Among all these authors, one of the major points used to demonstrate inefficacy of reforms is that maize output per caput has stagnated during the period of price reform except for the 1981/82 season in which maize prices were abruptly increased relative to other smallholder crop prices. Increases in output have resulted from the expansion of maize into the last remaining cultivable area rather than improved yields. They conclude that only land-augmenting technical change (seed-fertilizer transformation) can generate price-responsiveness in the aggregate supply curve.

The fundamental problem with this perception is that, because maize is produced in a household production process as the primary starchy staple, an increase in price can lead to a decrease in marketed maize and a welfare loss for households who are net buyers of maize (food-deficit households). To assure their subsistence requirements under conditions of production and marketing uncertainty, farmers may actually sow a greater proportion of their farm area in maize as the price increases. Even after market liberalization, prices convey little relevant economic information for decision-making and farmers may not appear highly price-responsive even for hybrid maize which remains more of a cash crop than local maize (Smale, 1992). The quality and reliability of rural marketing infrastructure, although high by sub-Saharan standards (Sofranko and Fliegel, 1989), affects aggregate response to price incentives (Sahn and Arulpragasam, 1991).

Limited changes in marketed maize output or even in actual maize production per caput may mask underlying technical changes within regions and farm households. The second problem with the findings reported in the cited sources is that, because of their emphasis on national data, technical changes that have occurred in maize production are less perceptible.