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Agribusiness and Public Sector Collaboration in Agricultural Technology Development and Use in Zimbabwe:

A Study of Cereal Seeds Development Technology

November 1992

AGRICULTURAL MARKETING IMPROVEMENT STRATEGIES PROJECT

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AGRIBUSINESS AND PUBLIC SECTOR COLLABORATION IN AGRICULTURAL TECHNOLOGY DEVEVLOPMENT AND USE IN ZIMBABWE: A STUDY OF CEREAL SEEDS DEVELOPMENT TECHNOLOGY

Submitted to
USAID/AFR/ARTS/FARA

Agricultural Marketing Improvement Strategies Project (AMIS)

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GLOSSARY

AFC	Agriculture Finance Corporation
AGRITEX	Agricultural, Technical and Extension Services
AID	Agency for International Development
AMA	Agricultural Marketing Authority
ARC	Agricultural Research Council
ARF	Agricultural Research Fund
ARTS	Agriculture Research and Technical Service
BSc	Bachelor of Science
CA	Communal Area
CBI	Crop Breeding Institute
CFU	Commercial Farmers' Union
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
COFRE	Committee for On-Farm Research and Extension
CPI	Consumer Price Index
DR&SS	Department of Research and Specialist Services
EEC	European Economic Cooperation
ENDA	Environment Development Activities
ESAP	Economic Structural Adjustment Program
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GMB	Grain Marketing Board

GNP	Gross National Product
GOZ	Government of Zimbabwe
HT	Helminosporium turcicum
FARA	Food, Agriculture and Resource Analysis
IARC	International Agricultural Research Center
ICFA	Indigenous Commercial Farmers' Association
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
IITA	International Institute for Tropical Agriculture
IPR	Intellectual Property Rights
LSCF	Large-Scale Commercial Farmers
MIC	Ministry of Industry and Commerce
MLARR	Ministry of Lands, Agriculture and Rural Resettlements
MSc	Master of Science
NR	Natural Region
NFAZ	National Farmers Association of Zimbabwe
NGO	Nongovernmental Organization
NPA	Non-Project Assistance
OPV	Open-Pollinated Variety
PhD	Doctor of Philosophy
PTA	Preferential Trade Area
R&D	Research and Development
R&SS	Research and Specialist Services

SSA	Sub-Saharan Africa
SACAR	Southern African Center for Cooperation in Agricultural Research
SADCC	Southern Africa Development Coordination Conference
USAID	United State Agency for International Development
UZ	University of Zimbabwe
ZFU	Zimbabwe Farmers' Union
ZNFU	Zimbabwe National Farmers' Union
ZSMA	Zimbabwe Seed Maize Association

EXECUTIVE SUMMARY

Background and Objectives

This study on biological technology examines maize, sorghum, millet, wheat, and barley seeds in Zimbabwe, as part of five case studies on agricultural technology development and use conducted by the Agricultural Marketing Improvement Strategies (AMIS) Project for AID/AFR/ARTS/FARA. The specific objectives of this study are to: (1) identify the key participants and their roles in the development, production, and stewardship[1] of cereal seeds; (2) estimate the amount of resources devoted to research and technology development for each specific crop; (3) investigate specific constraints that affect private sector technology development and sale and the collaboration between public and private sectors; and (4) suggest potential roles for A.I.D. assistance to both the public and private sectors.

This study is based on a review of documents from a phase I field study, discussions with in-country consultants, and detailed interviews with a subset of private firms and public institutions involved in the development and transfer of cereal seed technology. Throughout the document, seed technology is used in its broadest sense to include all aspects of research and development.

Situational Analysis

The Demand for Cereals and the Cereal Commodity System

Cereals play an important role in Zimbabwe, particularly white maize, the staple food. Consumption of sorghum, pearl and finger millet is declining, yet these crops remain the best suited to fragile lands, which are cultivated by most small farmers. In recent years, Zimbabwe has remained a significant maize exporter to neighboring countries, with exports averaging 300,000 tons a year since independence in 1980. This year (1992), a severe drought is forcing Zimbabwe to import about 1.7 million tons of maize. The demand for wheat is growing rapidly, pushing Zimbabwe into a "wheat trap" because the country lacks comparative advantage in wheat production. Malting barley is in high demand by the local and regional beer industries.

The cereal marketing system is highly regulated, with controls on prices and movements across zones. Transport constraints have compounded these regulations, adding to a lack of integration in the cereal marketing system. Market liberalization efforts, initiated since 1990, are still limited in scope.

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[1] Stewardship concerns supporting services that promote and distribute technology products to users. Stewardship includes extension, information, training, financing, and distribution efforts.

The Demand for Improved Seeds

Zimbabwe is unique within Sub-Saharan Africa (SSA) for its widespread use of hybrid maize seed, which is now planted on 90 percent of its maize-growing area. Beginning in the 1950s, this use expanded over the years, with the most spectacular success occurring after Zimbabwe gained independence, when smallholder farmers adopted hybrid seed en masse. Factors contributing to this success were improved input delivery, increased access to formal credit and markets, stable seed and maize prices, and better public extension services. During the 1980s there was a strong political commitment to promoting the use of hybrid seeds, capitalizing on a strong demand for maize and a technology already on the shelf.

The factors that brought success with hybrid maize have yet to be duplicated for sorghum and millet. Smallholder farmers are attracted to hybrid maize over sorghum and millet because maize yields are higher (during years of sufficient rainfall). Hybrid maize also responds better to good management, and demands less labor in production and post-harvest processing activities. Although not as important as maize, wheat and barley have remained of considerable interest to farmers who have access to irrigation.

Research, Development, and Production of Cereal Seeds

Crop Breeding Programs. The maize breeding program of the Department of Research and Specialist Services (DR&SS) started in Zimbabwe in 1932. It was second after the US to release, in the 1960s, a true single cross hybrids (SR52). DR&SS generates single, three-way, and modified single hybrid crosses, though it usually labels modified single crosses as true single crosses. A single-cross has two unrelated parents (A x C), and a 3-way cross three [(A x B) x C)].[2] Increasingly, breeders in Zimbabwe generate three-way hybrids (over 92 percent of Seed Coop's 1991/92 sales), a trend opposite to that of the United States and Europe, where breeders have established that, on average, 3-ways yield less than single crosses. Three-ways are dominant in Zimbabwe because they are believed to have more seedling vigor (to resist drought stress) and higher, more stable yields in seed production (to lower seed cost). More surprising is the longevity of Zimbabwe's successful maize hybrids. Four (30 percent) of the hybrids released during the 1976/77 season or earlier still make up 84.5 percent of the 1991/92 sales of Seed Coop, which has a near monopoly. This market share of 15-year or older hybrids is truly unusual in competitive seed markets. Also highly unexpected is that the two best-selling hybrids, with over 80 percent of sales, are extremely close in genetic makeup. The germ plasm base of the maize hybrids grown in Zimbabwe is surprisingly limited.

Other institutions in maize breeding programs in Zimbabwe include Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT), the international institution for maize and wheat research (since 1985), and three private seed houses -- the local Seed Coop

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[2] In a modified single cross, the female parent has two related lines and the male inbred is unrelated to either female inbred parent ($[A_1 \times A_2) \times C)]$.

(since 1973), and two US firms, Pioneer Hi-Bred (since 1988), and Cargill (since 1991). So far, Seed Coop has released two hybrids, Cargill none from its own program, while Pioneer is poised to introduce its first hybrids next season.

DR&SS also conducts breeding programs in sorghum (since 1969), pearl millet (since 1977), finger millet (since 1988), irrigated wheat (since 1980), rainfed wheat (since 1985), and barley (since 1960). The department has released several wheat and barley cultivars, but only three sorghum, one pearl millet, and no finger millet cultivars. The International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) started sorghum, pearl and finger millet breeding programs in 1987, and to date has developed a pearl millet cultivar. Seed Coop started an irrigated wheat breeding program in 1983, and the University of Zimbabwe a rainfed wheat program in 1989, but neither has released any cultivars thus far.

Seed Production. Tripartite and bilateral agreements between Seed Coop and DR&SS give exclusive rights to Seed Coop to produce and sell seeds developed by the public institution. In return, Seed Coop maintains seed stock representing 20 percent of the country's need. In 1986, a South African seed house (Pannar) obtained clearance to produce and sell five maize hybrids. Pioneer and Cargill are adding competition to hybrid maize production, although Seed Coop still maintains a dominant position. Seed Coop also remains the sole producer of sorghum, millet and wheat seeds. As for malting barley, the national brewery controls all its production.

Stewardship

The public extension department, AGRITEX, which has received substantial public support over the years, played a crucial role in success with hybrid maize during the 1980s. For more than 70 years, the Agricultural Finance Corporation (AFC) has provided loans to farmers. Since independence, the AFC has increased its loans to small communal farmers, as one important element of the "production packs" promoted by the government. Seed Coop maintains an elaborate seed distribution network, linking its appointed distributors to independent wholesalers, urban and rural retailers, and farmers' cooperatives. Other private seed houses have a more streamlined distribution network, targeting particular farmers.

Patterns of Collaboration

Actual patterns of collaboration between public and private sectors involve exchanging crop-breeding materials, conducting research, financing research, servicing seeds, and promoting stewardship. Formal mechanisms for exchanging breeding material include the mandate of CIMMYT and ICRISAT, which calls for release of germ plasm gratis to national pubic research institutes. Other formal mechanisms include a licensing agreement between Seed Coop and DeKalb, and the outright purchase of Ciba-Geigy's hybrids by Cargill. Informal mechanisms include the exchange of material between DR&SS and the University of Zimbabwe (UZ); and, Seed Coop's access to DR&SS's germ plasm, since the agreement with DR&SS does not include release of genetic material to Seed Coop's own breeding program.

The collaboration between public and private sectors in conducting research also follows formal and informal mechanisms. DR&SS's testing of seeds for performance evaluation (advanced trials) for release and certification should follow established rules, but there have been complaints that these rules are not clear enough. Increasingly, the Agricultural Research Trust (ART), a private cooperative, is the independent organization to which seed houses turn for running trials.

Private seed houses and research institutions are financed through retained earnings and/or allocations from the mother companies. A distinct feature of the local private companies, Seed Coop and ART, is their true cooperative nature. Both government and private contributions to DR&SS cereal breeding programs and Seed Services have been grossly inadequate. Sadly, the department still lacks an appropriate mechanism to generate funds or attract private donations. This year DR&SS' funds ran out for the wheat and corn breeders to harvest summer trials and prepare their winter nurseries, and for Seed Services' field inspectors to certify seeds at the seed houses' farms. The corn breeder has asked CIMMYT for help and Seed Services is asking private companies to provide transportation to enable its inspectors to continue their activities. The situation is better at the UZ, which has been attracting external funds because of its autonomous status. However, a high staff turnover resulting from unattractive compensation is increasing the teaching load of the remaining staff and reducing their research time.

To promote their products to farmers, private seed houses generally seek the collaboration of AGRITEX.

Business and Regulatory Environment

Private seed houses are concerned about government controls on prices of commercial seeds. A seed house that wants to sell seeds in Zimbabwe must negotiate its prices with the price control authority, based on a "management account" (itemized cost of production) and a proposed profit margin. Since 1986, however, Pannar has successfully argued that seed prices should be based on the seed grower's opportunity cost. In the past, to circumvent the perceived low prices of seeds, Seed Coop offered smaller units (from 500 grams to 25 kg) priced proportionally higher than 50 kg units. In recent years, however, these markups have been lowered due to regulations and competition introduced by Pannar and Cargill. Since adequate competition exists within the seed industry, there is little need for government intervention in seed pricing, and price controls should be liberalized.

Intellectual Property Rights[3]

The passage of the Plant Breeders' Rights (PBR) Act 19 years ago illustrates the progressiveness of the seed industry in Zimbabwe. No litigation has occurred to date under this act, so no statement can be made about its effectiveness. Suffice it to say that such an act is in place and plant breeders' rights are being protected. Pioneer, Cargill and Pannar were in part attracted to Zimbabwe by the introduction of PBRs and the favorable business and climactic conditions. Protection is necessary more for self-pollinated species than for hybrids. For hybrid maize to realize its genetic potential, seed must be purchased each year by the farmer, in contrast to a self-pollinated cultivar which would breed with no loss of genetic potential when replanted by a farmer. Thus far, no institution has taken advantage of Plant Breeders' Rights (PBR) to license plant material.

Emerging Issues and Implications for the Future

Demand for Commodities and Seeds

Public officials would like to lessen Zimbabwe's dependence on white maize, by shifting consumer preference to other local crops, and production to higher value crops. The demand for maize, however, will continue to grow in Zimbabwe and in the region. Smallholders cultivate about 90 percent of the maize acreage, which increasingly includes marginal areas that often require replanting. Also, Zimbabwe is about to implement a land redistribution scheme, and more area will likely be planted to maize, increasing the demand for hybrid seeds. The demand for wheat and barley will also remain strong, but without much negative effect on maize. More problematic is how to sustain and develop the potential demand for sorghum and millet products and seeds, given that they may be more suitable from a production point of view.

Supply of Technology

To a large extent, private interests have always dominated the cereal seed industry in Zimbabwe. Private participation has increased even more with the entry of US and South African companies. These companies are only interested in hybrid maize for those farmers who consistently demand and can pay for hybrid seeds. This implies that public research institutions would still have two primary responsibilities regarding maize: first, to maintain maize germ plasm and, second, to develop hybrid maize for marginal areas. Public institutions have the primary responsibility for much of the research and development of improved varieties of sorghum and millet seed. For wheat, Seed Coop remains the major private sector player

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[3] Intellectual property rights are an entity's rights to any new technology developed by that entity. Protection of the research and development of new technologies assures that firms may profit from these new technologies, if they are willing to invest the monies necessary for their research and development.

because the wheat market is limited. As for barley, while DR&SS is strapped for funds, it would be logical for the brewers to take over the entire breeding program, since all the benefits accrue to the brewers.

Thus an important component in the debate over seed technology development in Zimbabwe regards the breeding of cereals for drought-prone areas, where most farmers grow food. Also at issue is the sustainability of public research organizations. Economic adjustment programs are reducing public funds for operations and salaries. How can DR&SS generate funds to supplement government allocations?

Prices and Other Regulations

Significant price increases are needed by private seed houses to provide a large enough margin for wholesalers to maintain an efficient and reliable distribution system, and to generate better profits and retained earnings for future investment in research and development. Zimbabwe recently signed an agreement with Canada to avoid double taxation of individuals and companies with interests in both countries. When applied to all countries, this agreement is likely to increase the after-tax profit that multinational seed houses may repatriate. This added flexibility increases the resolve of multinationals to invest in Zimbabwe.

Collaboration Between Public and Private Sectors

Many observers believe that the Tripartite and the Bilateral Agreements giving Seed Coop exclusive rights will be amended, but not scrapped. The agreements have worked well thus far for both Seed Coop and the country. Also, since Seed Coop has only one proprietary line in its 3-way maize hybrids, it would not be to its advantage to sever ties with DR&SS.

Public and private plant breeders in countries such as the United States used to share knowledge in breeding methods and program activities. However, increased awareness of intellectual property rights, plant patents, and trade secrets have somewhat restricted this free exchange of ideas among breeders. In Zimbabwe, collaboration between national and international public institutions in seed research may occur during the breeding or product development phase. However, collaboration at that stage is highly unlikely to occur between private sector companies and public sector groups. The release of plant material by international research centers to the public, including private seed houses, will undoubtedly enlarge the genetic base of cereal crops. It would also encourage more collaborative tests between the private sector and international research centers.

Conclusions and Recommendations

Conclusions

Overall, Zimbabwe possesses an efficient seed industry, especially in hybrid maize. Zimbabwe's hybrid maize seed industry is a truly unique success story in SSA, in terms of

breeding programs, efficient production and stewardship of seed, and saturated adoption level. The success with hybrid maize, however, has not been replicated in sorghum and millet, although these crops appear better suited to drought-prone, food-insecure areas.

A key lesson learned in Zimbabwe, notwithstanding its unique history, is that technology can be generated within SSA. Another lesson, learned recently, is that realization of the potential demand for a technology is easier when the technology is on the shelf (maize) than when it still has to be generated (in sorghum and millet).

Despite its success, hybrid maize is showing a few alarming signs. Three-way crosses dominate single crosses, 15-year-old hybrids make up more than 84 percent of the sales, and two closely-related hybrids make up more than 80 percent of the sales. The genetic base of hybrid maize is limited. Fortunately, the increased participation of CIMMYT, US, and South African private seed houses will enlarge this genetic base.

There is ample participation by the private sector in the hybrid maize seed industry in Zimbabwe. This study confirms the proposition that where technology has a market and the characteristics of a private good, the private sector will step in, provided government regulations are not too restrictive. This participation does not stop at seed distribution, but can include product development, testing, and seed production. However, when the technology product lacks the characteristics of a private good, market potential, and government support, the private sector will not participate. This implies a certain division of labor between the public and private sectors. The question then is how to encourage both an increased participation of the private sector and a more focused, collaborative role of the public sector. A particularly difficult issue is how to sustain public institutions that target difficult, though critical areas of research.

Recommendations

Crop Breeding. Greater efforts should be made to develop earlier maturing and more drought-tolerant white maize cultivars. A system for evaluating experimental hybrid maize performance under an adequate range of conditions representative of Zimbabwe should be established. More testing locations per year will reduce the number of years required to adequately sample this range of environments. Programs should compare several hybrids and cultivars of maize and small grains (sorghum and millet) in the same trials in drought-prone areas under typical communal farm conditions.

Financing Research. In order for DR&SS to generate funds, DR&SS will require a special status, similar to the one enjoyed by the University of Zimbabwe. Financial autonomy would allow DR&SS to provide services at cost and keep the proceeds for its programs. Its staff could also be taken off the general civil service salary schedule, and thus receive better incentives to stay with the department. Experience is important to ensure research excellence, and success depends on career longevity of key professional personnel.

Strengthening Seed Services. DR&SS needs to consider setting up a two-track system. One track would consist of strengthening the present system involving the Release Committee, seed certification and Plant Breeders' Rights. The second would involve the production of standard seed (non-certified) with or without Plant Breeders' Rights.

Under this system, data from ART's trials would be released to the public. For those groups wishing to certify and/or to apply for Plant Breeders' Rights, these data would be evaluated by the DR&SS Release Committee. This committee should be formalized and restructured to include members from the private seed companies doing business in Zimbabwe, when their plant species are involved. The Release Committee of DR&SS would not be involved in cultivar or hybrid releases from private seed companies if certification is not requested. Private seed companies could request Plant Breeders' Rights for non-certified releases by applying to Seed Services if they chose since Plant Breeders' Rights and certification are separate entities.

Promoting Greater Participation of Private Seed Houses. Greater participation of private seed companies may be facilitated in several ways. For example, the Bilateral and Tripartite Agreements could be amended to allow release of lines to Seed Coop and other private companies as well, on a paid royalty basis; price and regulatory controls could be liberalized; enactment of PBR and similar protection could be promoted in countries other than Zimbabwe and South Africa to facilitate inter-regional trade, which is an important part of the *raison d'être* of all private seed houses in Zimbabwe.

Recommendations to USAID. USAID can play a significant role by implementing the following recommendations:

- Provide long-term commitment to support research by public organizations in plant-breeding programs for crops that are strategic for food security, but not profitable for seed development by the private sector.

- Promote exchange of breeding material between US public institutions and plant breeders in Zimbabwe.

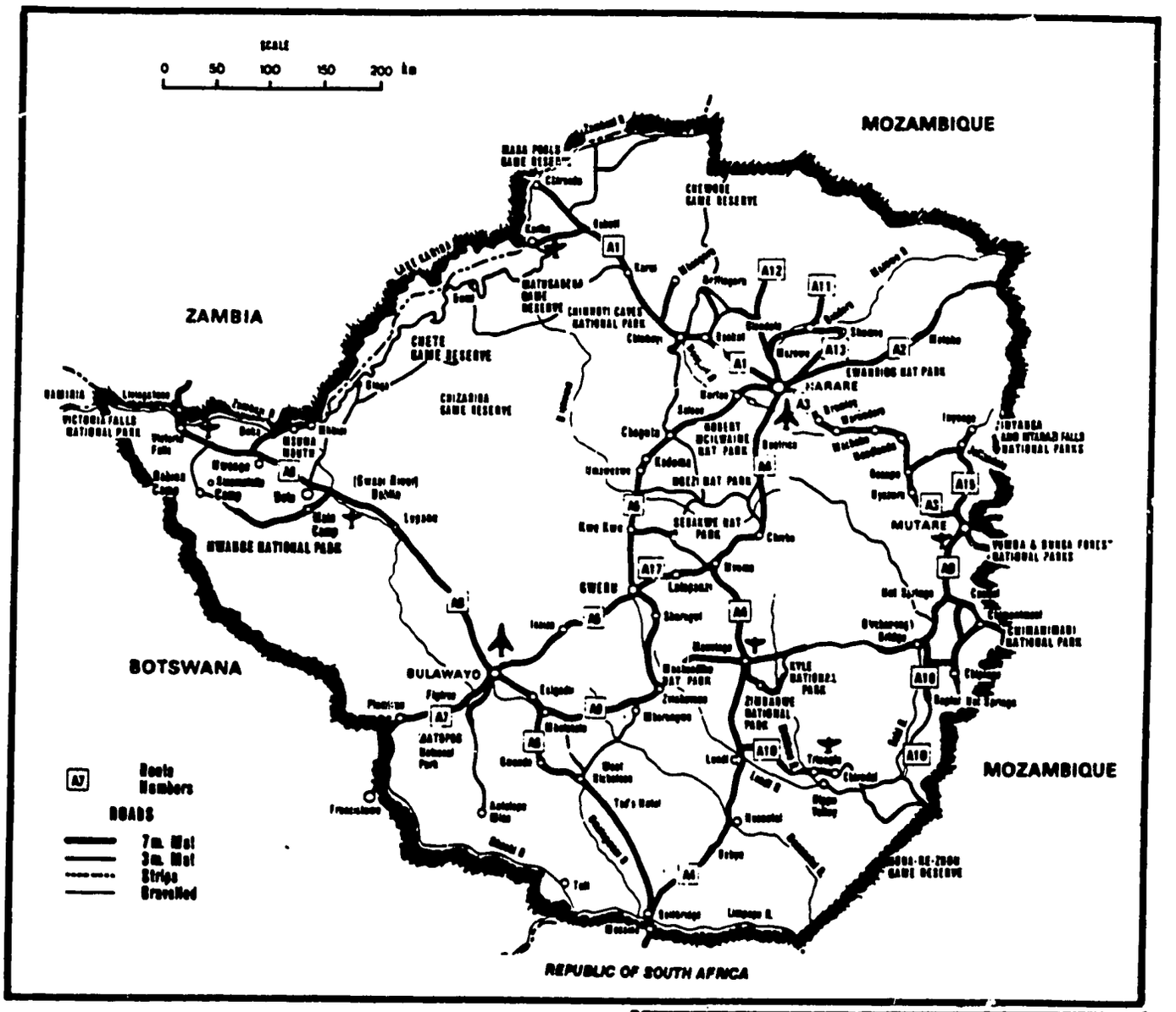
- Enhance the sustainability of national public research institutions. USAID may use non-project assistance (NPA) programs as leverage, in collaboration with other donors, to hasten measures for cost recovery and revenue generation capability of these organizations. Removal of price controls could possibly be used as conditionality for further NPA programs.

- Promote regional standards in IPR and contract enforcement. USAID should help Eastern and Southern African countries enact such regulations, again using the leverage of country or regional NPA programs.

- Promote local participation in the seed industry. To increase greater understanding of the private sector in Zimbabwe, USAID should organize study tours to expose the new generation of plant breeders, government officials and emerging local private seed houses to the US private seed industry.

MAP

ZIMBABWE



INTRODUCTION

1. BACKGROUND OF THE STUDY

The Africa Bureau of the United States Agency for International Development (A.I.D.) is building a Strategic Framework for Agricultural Research in Africa to describe and analyze the role of agribusiness and its relationships with the public sector in agricultural technology development and use in Sub-Saharan Africa (SSA). The Strategic Framework aims to help balance the demand for and supply of technology, at higher and higher levels of technology utilization, to bring about sustainable growth in Sub-Saharan Africa's agriculture. This activity supports the Bureau's efforts to encourage the increased contribution of local and U.S. agribusinesses to the goal of sustainable, broad-based, market-oriented growth of Sub-Saharan African economies. The output from this activity will improve USAID Missions' and host country research policy makers' ability to understand and more confidently make informed decisions about the relative roles of the public and private sectors in agricultural research technology development and use.

Five field studies, in two phases, examined four types of technology (biological, mechanical, agrichemical, and processing)[1] to analyze (1) the interaction between the technology development and sales system, and the production and marketing of the commodity; (2) the involvement of private sector technology firms in the production and marketing of cereal seeds; and (3) instances of successful collaboration between the public and private sectors in agricultural technology development and transfer.

This study on biological technology examines maize, sorghum, millets, wheat and barley seeds in Zimbabwe. Its specific objectives are to: (1) identify the key participants and their roles in the development, production, and stewardship[2] of cereal seeds; (2) estimate the amount of resources devoted to research and technology development for each specific crop; (3) investigate specific constraints that affect private sector technology development and sale, and collaboration between public and private sectors; and (4) suggest potential roles for A.I.D. assistance to both the public and private sectors.

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[1] The five field studies are: agrichemical technology for maize and other cereals in Cameroon; processing (post-harvest) technology for fruits in Ghana; processing (feed) technology for poultry in Kenya; mechanical technology for cotton in Mali; and biological technology (seed) for cereals in Zimbabwe.

[2] Stewardship concerns supporting services that promote and distribute technology products to users. Stewardship includes extension, information, training, financing, and distribution efforts.

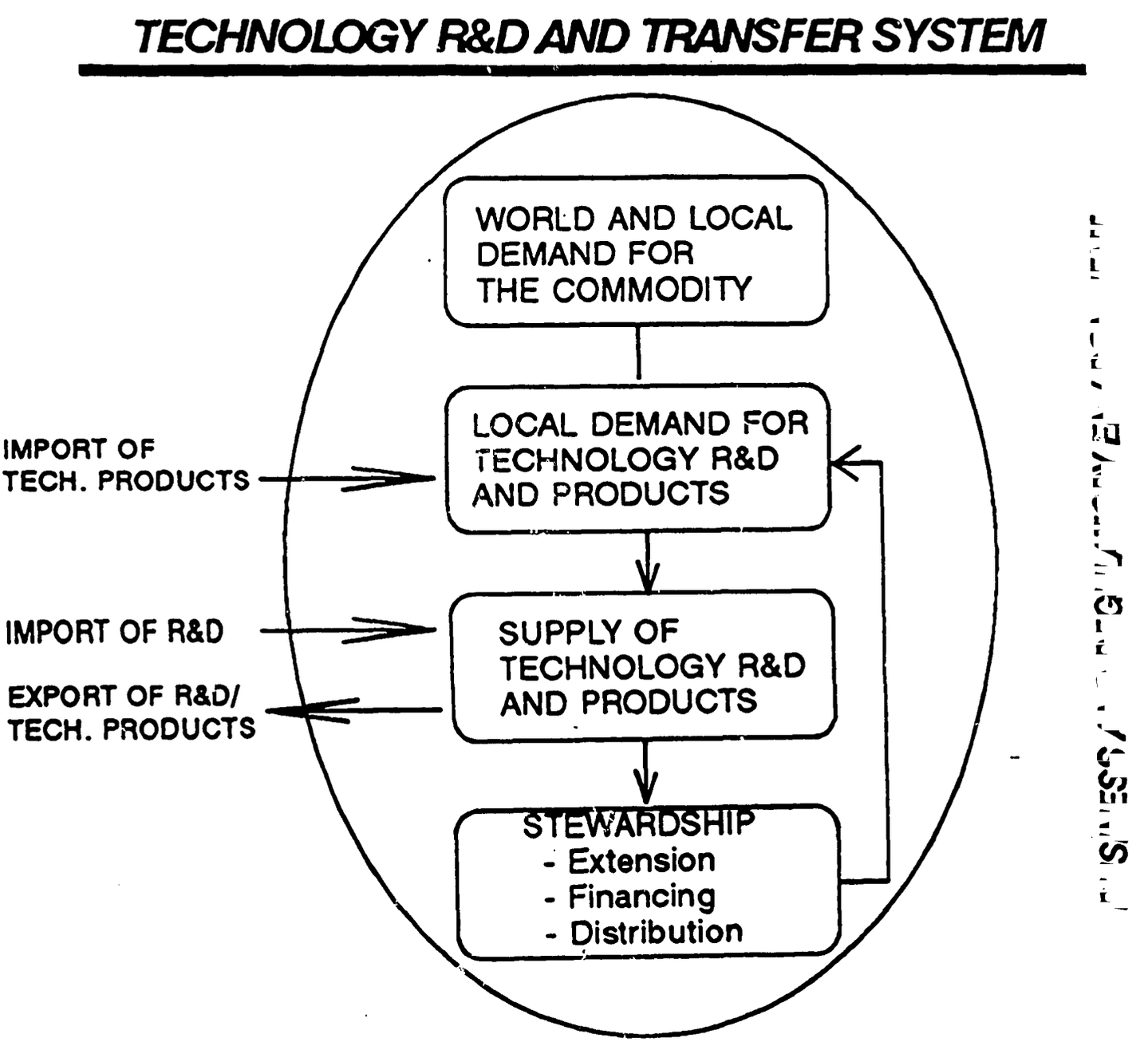
2. FRAMEWORK OF THE STUDY

The underlying rationale for the development and use of a technology is shown in Exhibit 2.1. Actual or potential demand for a commodity induces the demand for the technology necessary to produce that commodity. In turn, this derived demand for technology affects the supply and the stewardship of technology. The feedback loop from R&D and stewardship to the demand for technology is critical in sustaining or dampening that demand. Therefore, to analyze the development and use of technology, one must identify and understand the driving forces behind the demand for the commodity or commodities of interest; the determinants of, and prospects for increasing the demand for technology; technology research and development; and the stewardship necessary to facilitate the most effective use of technology.

This study on seed research and development in Zimbabwe follows this rationale. It is based on a review of documents from the Phase I field study and detailed discussions with in-country consultants and a subset of private firms and government institutions involved in the development and transfer of cereal seed technology. Throughout this document, seed technology is used in its broadest sense to include activities in R&D.

This document contains three parts. Part I describes and analyzes the importance of cereals in Zimbabwe's economy, the demand for improved seeds, cereal crop breeding and seed production, distribution of seeds, patterns of collaboration between public and private sectors, the business and economic environment, and plant breeders' rights. Part II analyzes key issues in seed technology and their implications for the future. Part III concludes the report and suggests potential roles for AID/ARTS/FARA and field missions. This introduction sets the stage for the rest of the report by providing an overview of Zimbabwe's key economic features.

Exhibit 2.1: Technology R&D and Transfer System



3. OVERVIEW OF ZIMBABWE'S KEY ECONOMIC FEATURES

Several distinctive features set Zimbabwe apart from most other SSA countries. Zimbabwe is a mid-altitude, highland tropical country, at the crossroads of Southern and Eastern Africa (see map). It is the largest trading partner of South Africa, the dominant economy in Africa, although the two countries have no formal relations. Zimbabwe, which gained independence in 1980, bears deep marks from its long and recent colonial history. The country has inherited a severely skewed land distribution. A minority of about 4,500 large-scale commercial, white farmers cultivate 29 percent of the (mostly prime) land in the country, while more than 1,000,000 families of the majority of producers, communal, African farmers, cultivate 42 percent of the land, in mostly marginal areas (World Bank 1991). Zimbabwe also maintains the overregulated economy set up by the rebel colony to fight international sanctions and preserve the interests of the ruling minority. Zimbabwe, however, also inherited a diversified economy, contrary to many other SSA countries, which rely on a few primary commodities. In 1989, the sectoral shares of the Gross Domestic Product (GDP) were made up of 43 percent in industry, 46 percent in services, and 11 percent in agriculture. The total contribution of Agriculture to the economy, however, was more significant than its share in GDP. The sector accounts for about 40 percent of total merchandise exports and 70 percent of formal employment (World Bank 1991).

The performance of Zimbabwe's economy was impressive in the early years after independence. For the balance of the decade, however, except in the late 1980s, the country experienced negative economic growth. Exhibit 3.1 shows this mixed performance in terms of real GDP and GNP, and inflation. Weather conditions played a significant role, with good rains in the first years after independence, and severe droughts in 1982/83, 1983/84, and 1986/87. Economic policies were also instrumental. The rapid growth of public institutions, the measures undertaken to redress social imbalances, and the overregulated economy contributed to lower private investment. Yet agriculture has achieved important successes after independence, notably in hybrid maize, but recurrent droughts (in 1990/91 and 1991/92) and continued stifling economic policies have denied the sector its expected growth.

Exhibit 3.1

Zimbabwe: Selected Economic Indicators

Rates	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Real GNP	10.6	12.5	2.6	1.6	-1.9	6.8	2.6	-1.5	7.0	5.5
Real GDP	7.8	9.7	-0.2	-1.2	-4.7	4.0	-0.2	-4.0	4.2	1.7
CPI	4.4	13.1	10.7	23.1	20.2	8.5	14.3	12.5	7.1	15.0

Source: World Bank, 1991.

PART I: SITUATIONAL ANALYSIS

4. ZIMBABWE'S CEREAL SUBSECTOR: THE DEMAND FOR CEREALS

Cereals play an important role in Zimbabwe, in food security (maize, wheat, sorghum, and millet) and agribusiness (barley, wheat, and maize). Exhibit 4.1 shows that from 1988 to 1990, total cereal production declined but remained strong in Zimbabwe.

Exhibit 4.1

Zimbabwe: Cereals Production ('000 tons)

CEREALS	1979-81	1988	1989	1990
Maize	1,829	2,253	1,927	1,993
Wheat	179	257	285	325
Millet	153	278	142	143
Sorghum	71	176	76	90
Barley	27	27	29	30
TOTAL CEREALS	2,259	2,993	2,461	2,583

Source: FAO Yearbook Production 1990, Statistics Series No. 99.
Note: Total may be greater than the sum of the listed figures because minor crops (rice and oats) are not accounted for.

4.1 The Demand for Maize

From 1986 to 1988, per capita maize utilization in Zimbabwe was 177 kg/year, with an average annual growth rate of 0.6 percent from 1973-77 to 1984-88 (CIMMYT 1990). Maize is used for food (64%), animal feed (22%), and other uses (14%) such as brewing. Maize accounts for 70 percent of the cereal calories in the average diet according to FAO (Rohrbach 1989 p.2). It is the primary staple in Zimbabwe and throughout Eastern and Southern Africa as well. Consumers in these regions have a strong preference for white maize, whose flour (mealie-meal) is cooked into a paste (sadza) and eaten with vegetable sauce. Yellow maize is mostly used in animal (poultry) feed and in brewing beer.

Exhibit 4.2 shows the importance of maize in the Southern Africa Development Coordination Conference (SADCC) countries. The size of net imports in most countries is a clear indication of the demand for maize from surplus countries (such as Zimbabwe, until last year). The country started exporting maize as livestock feed in 1914, mostly to Europe

(CIMMYT 1989). In recent years Zimbabwe has remained a significant maize exporter to neighboring countries, with exports averaging 300,000 tons a year since independence, in 1980 (The Herald, Saturday 11 April 1992, p.1).

Exhibit 4.2

Maize Import and Utilization in SADCC Countries (1986-88)

Countries	Net Imports ('000 MT)	Per Capita Utilization (Kg/year)	Food Use of Maize (Percent)	Feed Use of Maize (Percent)	Other Use of Maize (Percent)
Angola	60	37	84	3	13
Lesotho	36	91	82	7	11
Malawi	1	171	83	5	13
Mozambique	175	34	90	0	10
Namibia	NA	NA	88	2	10
Tanzania	-75	99	92	2	7
Swaziland	12	156	65	14	21
Zambia	66	190	79	3	17
Zimbabwe	-345	177	64	22	14

Source: CIMMYT, 1989.
Note: Negative numbers indicate that the country is a net exporter.
NA: Data not available or incomplete.
There is no data available for Botswana.

In 1992, though, for only the third time in the past 75 years (Business Herald, 9 April 1992, p.5), Zimbabwe is importing about 1.7 million tons of maize to meet local demand. Cereal production dropped 20 percent, below a 30-year normal, following the region's worst drought; contributing factors were also lack of production incentives and failure of authorities to act promptly[1] once early warnings were given. Monthly local demand for maize is expected to rise from the usual 100,000 tons to between 140,000 and 150,000 tons, as communal farmers did not satisfy their consumption demand from retained harvests.

4.2 The Demand for Sorghum and Millet

Sorghum and millet were the dominant cereals before the introduction of maize, about a century ago. According to ICRISAT, pearl and finger millets are balanced, nutritious cereals, with high levels of fiber and minerals. Finger millet, for example, is the traditional foodstuff given to pregnant and lactating women because of its high calcium content. Production of small

grains varies between 200,000 to 400,000 tons per year and accounts for 15 percent of the calories available from cereals (World Bank 1991, p.99).

More and more, however, these grains are losing ground to white maize. Farmers report that millet and sorghum are more time consuming to produce, harvest and process (especially with hand pounding) than maize; they are also not available in the same convenient form ("mealie meal" flour) as maize. Yet, the preference for maize over millet and sorghum sadza may be stronger for young urban generations than the rural population. The beer industry also provides an important outlet for malting (red) sorghum and millets. The local, unpasteurized but industrially brewed beers use red sorghum ("chibuku" beer) and "mhunga" ("rufaro," opaque beer).

4.3 The Demand for Wheat

The demand for wheat is growing rapidly in Zimbabwe, to the extent that the Agricultural Marketing Authority (AMA) estimates that bread may be replacing maize sadza as the staple in the lunchtime meal (AMA 1989). The actual demand for local wheat, however, is difficult to estimate because of import restrictions. Some estimates had put total wheat requirements at 350,000 tons for 1987/88 and 365,000 tons for 1988/89. Wheat allocations, on the other hand, were 270,992 tons and 287,841 tons, respectively, about 77 and 79 percent of requirements (AMA 1989). The GOZ fears that liberalizing wheat imports could hurt the maize subsector.

Wheat production is supported by subsidies because the country lacks comparative advantage in growing wheat (World Bank 1990). In 1985, the Agricultural Finance Corporation (AFC) set up a National Farm Irrigation Fund to encourage irrigated wheat production to achieve near self-sufficiency in wheat. The AFC has thus far advanced funds worth Z$ 30 million to farmers (The Herald, 31 March 1992, p.4).

4.4 The Demand for Barley

Zimbabwe grows, under irrigation, about 82,000 tons of malting barley for local use in the beer industry and, since 1978, for export. According to National Breweries, which contracts for all barley grown in Zimbabwe, 50 percent of this production is now exported. Importing countries include South Africa, Botswana, Madagascar, and other Preferential Trade Area (PTA) countries, including Ethiopia and Uganda. Zimbabwe contends that its barley is of superior quality to the one exported by the European Economic Community (EEC) to other SADCC countries.

Throughout the region, the demand for beer is strong. A new company is reportedly setting up a brewery to compete with National Breweries Ltd, the sole brewer in the country. National Breweries is also expanding (with a US$ 100,000 investment plan) for the home and international markets. Last year, National Breweries won a gold medal in the light lagers category for its Zambezi Premium Export Lager at the International Beer Show in Toronto, Canada.

4.5 The Cereal Marketing System

Zimbabwe inherited a heavily regulated cereal marketing system, with price fixing and controls on crop movements, purchases, storage, and local and export sales. Input distribution is also regulated. At independence, these regulations were continued out of expediency; they were later used to extend services to communal farmers who were denied public support in the colonial era.

Several institutions play an important role in cereal marketing. The Ministry of Lands, Agriculture and Rural Resettlement (MLARR) oversees the parastatals, sets producer prices, and reviews applications for import licenses. The Ministry of Commerce administers wholesale and retail prices of commodities and inputs (including fertilizer and seeds). The Agricultural Marketing Authority (AMA), created in 1967, advises the government and marketing boards, and mobilizes finances for local and imported grain purchases. The Grain Marketing Board (GMB) buys, stores, sells, and exports the controlled commodities.

Two strong unions represent producers' interests. The Zimbabwe Farmers' Union (ZFU) is a merger of the National Farmers' Union of Zimbabwe (NFAZ), representing smallholder farmers in the communal areas, and the Zimbabwe National Farmers' Union (ZNFU), representing some 10,000 small-scale commercial farmers in the former African Purchase Areas. The Commercial Farmers' Union (CFU) represents some 4,500 white, large-scale commercial farmers (LSCF). The CFU has formed several producers' associations[3], including the Commercial Grain Producers' Association, and the Zimbabwe Cereal Producers' Association.

Seed Coop, the dominant local seed house, which grows and market seeds, is formed by some 250 members of the CFU. For other inputs, agricultural suppliers coordinate their activities through associations, notably the Agricultural Chemical Industry Association, and the Dealers and Manufacturers' Association.

The government sets prices, and controls procurement, storage, and sales of controlled grains (maize, wheat, and white sorghum). It sets floor prices of regulated grains (red sorghum, and pearl millet), allowing free marketing, with the marketing board as the residual buyer. For liberalized grains (barley and finger millet in 1991/92), there are no official prices and no control of marketing. Floor pricing and limited free movement of grains are changes introduced since 1990 by the GOZ in an attempt to liberalize the marketing system. There remains the

[3] Other crop associations include the Commercial Cotton Growers' Association, the Commercial Oilseeds Producers' Association, and the Coffee Growers' Association.

distinction between areas A and B[4], cutting across Natural Regions (NR), which helps maintain an overregulated system.

Marketed surplus of the staple white maize produced in Area A (LSCF) must be delivered to the GMB. Some lower grade white maize, however, may be retained by commercial farmers for their workers and for animal feed. Communal farmers may sell white maize in local areas, but movements across communal zones and to area A remain prohibited. The marketing of yellow maize (entirely produced by LSCF) is now liberalized, allowing sales from producer to producer, provided that all transactions remain within farming association area (i.e., A to A, and B to B) and are reported to the GMB. The GMB remains a residual buyer of the crop, whose price is set 15 percent below the price of white maize because yellow maize is reported to yield 15 percent more than white maize.

These measures were taken to reduce the huge stocks carried by the GMB. Because users may now buy directly from farmers, the GMB should handle reduced quantities of yellow maize (for animal feed), and red sorghum (e.g., brewers used to buy 30,000 m.t. of red sorghum from the board). The AMA estimates, however, that prices of regulated crops are still above market level, so that the GMB will still be handling a significant amount of the market surplus of small grains to stock and dispose of at a loss.

Perhaps, more than the restrictions on grain movements, reduced transport opportunities have contributed to the poor integration of the grain-marketing system in Zimbabwe. The previous economic sanctions against the country before independence and the continuing lack of foreign exchange have prevented Zimbabwe from adequately servicing and improving its transport fleet, though the road network remains excellent. In the early 1980s, opening more depots and registering more farmers effectively increased smallholder farmers' market access. In this drought year, transportation bottlenecks remain a major problem facing a country that must now import and distribute about 1.7 million tons of maize to its population.

[4] Area A comprises urban areas and all commercial farms, including previous commercial farms affected by resettlement. Area B includes communal farming areas. Before the recent changes, farmers in area A who produced controlled grains (which included all cereals except barley) had to sell their marketed surplus to the marketing board and may move commodities to the mostly deficit area B. Farmers in area B may market commodities within individual communal areas, except between CA and into area A. In part, such stringent regulations help credit collection when the marketing boards make payments to producers.

5. THE DEMAND FOR IMPROVED SEED

This section examines key determinants of the demand for improved seeds. It highlights the success story of hybrid maize seed, the neglect of sorghum and millet, and the special markets for wheat and barley.

5.1 The Success Story of Hybrid Maize in Zimbabwe

Zimbabwe is unique within Sub-Saharan Africa for its widespread use of hybrid maize seed, which is now planted over 90 percent of its maize-growing area. In other SADCC countries, the rate of adoption is much lower. Exhibit 5.1 shows that Zambia, Tanzania, and Malawi, the other larger producers and consumers of maize lag far behind Zimbabwe. (In other SADCC countries, the use of hybrid seed is almost non-existent). Kenya, another major maize producer and consumer in Eastern Africa, planted 55 percent of its maize area in hybrid maize seed in 1988 (CIMMYT 1989). Elsewhere, in West Africa, efforts are still concentrated on improving open-pollinated varieties (OPV) and hybrid maize seed is virtually unknown (CIMMYT, 1989).

Exhibit 5.1

The Use of Hybrid Maize in SADCC Countries

Zimbabwe	Swaziland	Lesotho	Zambia	Tanzania	Malawi
100%	75%	74%	45%	11%	2%

Source: CIMMYT, 1989.
Notes: No data is available for other SADCC countries.

Zimbabwe has achieved significant yield improvements in maize production over the years because of hybrid maize. From 1913 to 1950, maize yields stagnated at about 500 kg/ha (World Bank 1991, p.202). Yields began to improve in the early 1950s (1.4 tons/ha) with improved practices and the first attempts at using hybrid seeds. With the release of the first single cross (SR52) in 1960, yields improved significantly, and from 1966 to 1985 averaged over 4 tons/ha. In spite of this program, the use of hybrid maize remains confined to the large-scale commercial farmers (LSCF) in Natural Regions (NR) II and III.

The success story of hybrid maize was most spectacular after Zimbabwe gained independence, when smallholder African farmers adopted hybrid seed en masse. Consumers' strong preference for maize certainly played a necessary but not sufficient role for the wide use of hybrid maize in Zimbabwe. Contributing to this success were several other factors, such as input delivery, access to credit, access to markets, and prices (Exhibit 5.2). From 1979/80, the year before independence, to 1985/86, deliveries of fertilizer increased four times to match a similar increase in seed deliveries. Credit loans, in value, were increased over 80 times, and the number of farmers selling to the marketing board more than 12 times. Producer prices also

increased, although at a relatively modest level, until the end of the period, and seed maize prices remained stagnant until the end of the period.

The hybrid maize success story is also explained by improved services provided by the department of Agricultural, Technical and Extension Services (AGRITEX), which increased its number of extension agents from one per 1,200 farmers in 1980 to one per 800 farmers in 1988 (The Insider, February 1992).

Exhibit 5.2

The Use of Hybrid Maize Seed by Communal Farmers: Key Factors in The Success Story (Indices)

	Input Deliveries		Credit Loans		Market Access*		Prices	
Season	Seed	Fertilizer	#	Value	Registry	Depots	Maize	Seed
1979-80	100	100	100	100	100	100	100	100
1980-81	224	333	631	1,000	254	200	141	100
1981-82	324	356	1,058	1,885	508	333	141	101
1982-83	324	363	1,365	2,758	652	400	141	113
1983-84	402	393	1,754	5,269	737	433	164	113
1984-85	454	473	2,308	6,667	908	467	212	113
1985-86	471	482	2,720	8,104	1,238	667	212	141

Source: Rohrbach, 1989; World Bank, 1991.
Notes: * Registry for number of communal farmers registered by the Grain Marketing Board
Marketing years (e.g., 1980/81) follow growing seasons (e.g., 1979/80)

Clearly, the demand for hybrid maize seed was captured by a strong political commitment capitalizing on the strong demand for the commodity and an existing technology. Some maize hybrids that were originally developed for regions II and III were sufficiently well adapted to be introduced and utilized in communal areas in regions IV and V. This impressive push by the GOZ ended in 1985/86. By then, however, the saturation level for hybrid maize adoption had been reached. Although yields in the communal areas remain highly variable, they have improved, especially relative to most competing crops.

5.2 Sorghum and Millet

The factors that brought success with hybrid maize have yet to be duplicated for sorghum and millet. Because of weaker consumer demand for sorghum, past breeding efforts have mostly bypassed sorghum and millet in Zimbabwe. Where yields of maize in communal areas have significantly increased over the years, yields of sorghum and pearl millet have stagnated (Exhibit 5.3).

The traditional sorghum varieties available to communal farmers compete poorly against maize hybrids. Several elements favor maize: better manuring, earlier planting[5], better adapted material, and perceived better response to good management (Rohrbach, personal communication). Hybrid maize often yields more than sorghum even in drought years; when rainfall is favorable, maize substantially outyields sorghum and millet. Rohrbach (World Bank 1991) found that in the drought year of 1983/84, maize and sorghum had about the same yields in communal areas. In the better year of 1985/86, the average yield of maize (1.5 mt/ha) was about 2-3 times that of sorghum.

It appears that information has bypassed sorghum as well. During a meeting last year, many farmers and agricultural experts did not know about the existence of high-yielding sorghum varieties available in Zimbabwe; everybody, however, has heard about hybrid maize (Lee House, ICRISAT, personal communication).

Seed Coop is reportedly sometimes out of sorghum seed stock for communal farmers. This year, despite the drought, Zimbabwe appears to have enough maize seed, but not enough millet seed for next year's growing season.

Exhibit 5.3

Crop Yields in the Communal Areas: Maize, Sorghum, and Millet, 1970-89

Cereals	Yield 1970-72 (kg/ha)	Yield 1978-80 (kg/ha)	Yield 1987-89 (kg/ha)	Yield Growth Rate (%) 1970-80	Yield Growth Rate (%) 1979-89
Maize	646	668	1,046	3.3	6.7
Sorghum	473	459	500	1.8	1.1
Rapoko	1,333	410	487	-13.4*	1.7
Mhunga	416	346	487	-1.5	4.6

Notes: * Significant at 5 percent level. Source: Roth, 1990, cited by World Bank, 1991.

[5] Similarly, in the high plains of Texas, early planted maize has replaced sorghum.

5.3. Wheat and Barley

Although not as important as maize, wheat and barley have maintained considerable interest for farmers who have access to irrigation. Strong demands for wheat products (bread) and malting barley products (beer) help maintain the profitability of wheat and barley production. National Breweries, which buys all barley in Zimbabwe, has helped finance barley breeding since the 1960s.

6. RESEARCH & DEVELOPMENT AND PRODUCTION OF CEREAL SEED

This section analyzes cereal breeding and seed production by public and private organizations in Zimbabwe.

6.1 Technology Research and Development for Seeds

The continuum of plant research includes basic research, product development, performance evaluation testing, and crop production system research. Basic research involves developing a new understanding of basic plant processes, and new approaches and techniques for plant improvement, including biotechnology techniques. Product development research or plant breeding involves developing improved hybrids and cultivars containing the genetic tracts necessary to maximize plant performance and stability in the environmental conditions present in the intended growing areas. Performance evaluation testing research involves the actual exposure of different experimental genetic combinations to the range of environmental conditions anticipated to be present in the intended areas of use. Research on crop production systems (managerial technology) is really an extension of performance evaluation testing in which cultural practices become a factor in modifying the environment.

Breeding of improved hybrids and cultivars of cereal crop species requires several years as illustrated in Exhibit 6.1. If only one growing season is utilized per year for breeding and increasing seed, it will take approximately 14 years to breed and release a new hybrid or cultivar. This period can be reduced by several years if winter nurseries, greenhouses, and winter facilities are used. For interested readers, Appendix A provides a technical overview of the fundamentals of breeding cereals.

6.2 Crop Breeding Programs in Zimbabwe

In Zimbabwe, cereal research involves breeding, performance evaluation testing, crop production systems, and, to a much lesser extent, basic research. The University of Zimbabwe has started using biotechnology in the form of a "gene gun," but, thus far, for crops other than cereals.

Plant breeding programs in Zimbabwe for cereals, especially maize, continue to move forward based on a long tradition of excellence established in the decades of the 1940s, 1950s, and 1960s. Several excellent studies have been conducted on seeds in Zimbabwe, especially "The Zimbabwe Seed Industry" by Esbern Friis-Hansen (1991). Friis-Hansen's study will be used as the basis of this section with pertinent updating and extensions. This section will focus on the public and private sectors and the interaction between them with respect to the breeding programs for maize, sorghum, pearl millet, finger millet, wheat and barley. The organizations involved in plant breeding are listed in Exhibit 6.2, which identifies the breeders involved by name.

Exhibit 6.1

Illustration of a Conventional Plant Breeding Program

Year	Cross-Pollinated Species	Percent Homozygosis (Uniformity)	Self-Pollinated Species
	Maize		Sorghum, Millet, Wheat, Barley
1*	Plan and Make Cross		★Plan and Make Cross
2*	Self F1	0	★Self F1
3*	Grow F2 Generation, Self (Inbred) and Select	50.00	Grow F2 Generation and Select
4*	Grow F3 Generation, Self and Select	75.00	Grow F3 Generation and Select
5*	Grow F4 Generation, Self and Select	87.50	Grow F4 Generation and Select
6*	Grow F5 Generation, Self and Select Make Screening Crosses	93.75	Grow F5 Generation and Select
7	Grow F6 Generation, Self and Select Evaluate Screening Crosses	96.88	Grow F6 Generation and Select
8	Make Planned Experimental Crosses		Preliminary Replicated Performance Evaluation tests
9	Preliminary Replicated Performance Evaluation Tests		Intermediate Replicated Performance Evaluation Tests
10	Intermediate Replicated Performance Evaluation Tests		Advanced Replicated Performance Evaluation Tests (Produce Breeders Seed)
11	Advanced Replicated Performance Evaluation Tests (Produce Breeders Seed)		Produce Foundation Seed
12**	Bulk (Increase) Parent Inbred Seed		Produce Certified Seed
13	Produce Hybrid Seed		1st Year Cultivar Sold to Farmers
14	1st Year Hybrid Sold to Farmer		

Notes: * Year 1-6 could be reduced to 3 years if a winter nursery is utilized.
** Year 12 could be accomplished in off-season production.
★ Years 1 and 2 could be reduced to 1 year if greenhouse is used.

Exhibit 6.2

Cereal Breeding Programs in Zimbabwe - April 1992

Crop Species	Year Begun	Parent Organization	Headquarters	Breeder
Maize	1932	DR&SS	Crop Breeding Institute	Mr. Lewis Machida/ Mr. Takesure Rukweza (on Education Leave)
	1974	Seed Coop	Rattray-Arnold Research Station	Mr. Mike Caulfield/Mr. Paul Rupende/R.C. Olver (Part-time)/Rattray (Part-time)
	1985	CIMMYT	University of Zimbabwe Res. Farm	Dr. G. Brhane/Dr. Hiep Pham/Dr. Kent Short
	1985	University of Zimbabwe	University of Zimbabwe	Dr. Kingston Mashingaidze
	1988	Pioneer Overseas Corp	ART Farm	Mr. Barry McCarter/Mr. Gilbert Mutseyekwa
	1991	Cargill Zimbabwe (Pvt) Ltd	89 Kaguvi St, Harare	Dr. David Gilliland
Sorghum	1969	DR&SS	Crop Breeding Institute	Dr. Joseph Mushonga/Fisher Muza/Christmas Pasipanodya
	1985	ICRISAT	Matopos Breeding Station	Dr. Lee House/Dr. Tande Obilana
Pearl Millet	1977	DR&SS	Crop Breeding Institute	Dr. Joseph Mushonga/Fisher Muza/Christmas Pasipanodya
	1985	ICRISAT	Matopos Breeding Station	Dr. Mongo
Finger Millet	1985	ICRISAT	Matopos Breeding Station	Dr. Gupta
	1988	DR&SS	Crop Breeding Institute	Dr. Joseph Mushonga/Fisher Muza/Christmas Pasipanodya
Wheat-Irrigated	1954	DR&SS	Crop Breeding Institute	Anthony Mashiringwani
	1983	Seed Coop	Rattray Arnold Research Station	Ephriam Havazvidi
Wheat-Rainfed	1985	DR&SS	Crop Breeding Institute	Anthony Mashiringwani
	1989	University of Zimbabwe	University of Zimbabwe	Dr. Pangirai Tongoona
Barley	1971	DR&SS	Crop Breeding Institute	Sebastian Musendo
	1985	University of Zimbabwe	University of Zimbabwe	Prof. Schaupenhauser

Historically, cereal crop breeding in Zimbabwe has been centered in the Crop Breeding Institute (CBI) at the Department of Research and Specialist Services (DR & SS), Ministry of Lands, Agriculture and Rural Resettlement (MLARR). The institute is currently conducting plant breeding research and performance testing on each cereal crop species involved in this study. These programs, conducted by a minimum of personnel, are underfunded.

Over the years, plant breeding investigations of additional crop species have been initiated at the Crop Breeding Institute at the request of the government. However, appropriated government funds have not kept pace with the additional assigned responsibilities. Therefore, limited funds have become ever more restricted. Basic office supplies, work vehicles, travel funds for planting, note taking, and harvesting of trials are extremely short. Though the breeding programs in the Crop Breeding Institute were expected to become more involved with communal farmers in Natural Regions (NR) III, IV and V, funds were so short that on-farm trials in communal areas were discontinued several years ago. Additional funding is critically needed at the Institute if the quality of past research is to be continued in the future. The following sections discuss breeding programs for maize, sorghum, pearl millet, finger millet, wheat, and barley.

6.2.1 Maize Breeding

Maize breeding programs in Zimbabwe began in 1932 in the Department of Research and Specialist Services (DR&SS), a national public institution. One of the first true single cross hybrids grown commercially in the world was SR52, developed and released by this program. This program is considered to have excellent germ plasm. Hybrids released from the program are produced and marketed through Seed Coop, a national private enterprise, under the provisions of a Tripartite Agreement (1970) between the State, Seed Coop, and Farmers' Association. Seed Coop is a cooperative owned by an exclusive group of seed growers.

Maize hybrids sold by Seed Coop in the 1991/92 growing season appear in Exhibit 6.3. Seed Coop distinguishes only two types of hybrids: single crosses and 3-ways. In fact, though, it offers three types of hybrid crosses: single crosses (designated here as SX), modified single crosses (M-SX), and three-way crosses[6] (3-X). Exhibit 6.3 shows hybrid maize by the year of first release (sale), the type of cross, its maturity, its color, and the percent sales. Maize seed sales were over 95 percent white hybrids with less than 5 percent yellow hybrids. Seed sales were nearly 90 percent early hybrids, less than 3 percent medium maturity hybrids, and slightly more than 7 percent late hybrids. Similarly over 92 percent of the sales were 3-way cross hybrids, less than 5 percent modified single crosses, and approximately 3 percent true single crosses.

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[6] A single cross hybrid is a cross between two unrelated inbred lines (A x C). A modified single cross is a cross using a related line single cross as the female parent and an unrelated inbred as the male parent [$(A_1 \times A_2) \times C$]. A related line single cross female parent produces more seed than an inbred parent, but less seed than a true single cross parent. The quantity of seed depends on the degree of relationship of the related lines. A three-way cross hybrid is a cross between an unrelated single cross female parent and a male line unrelated to either inbreds in the female parent (A x B) x C. Seed yield of the female parent of a three-way cross should approach the yield level of a commercial hybrid.

Exhibit 6.3

Major Maize Hybrids Sold By Seed Coop in 1991-92

Breeder	Hybrid	Released	Type	Maturity	Color	% Sale
DR&SS	SR52	1960/61	SX	Late	W	2.95
DR&SS	R200	1970/71	3X	Early	W	0.45
DR&SS	R201	1974/75	3X	Early	W	38.97
DR&SS	R215	1976/77	3X	Early	W	42.17
DR&SS	ZS225	1981/82	MSX	Early	W	0.25
DR&SS	ZS107	1981/82	SX	Late	W	0.12
DR&SS	ZS206	1983/84	MSX	Late	Y	4.07
DR&SS	ZS233	1984/85	MSX	Late	W	0.31
DR&SS	ZS232	1987/88	MSX	Medium	Y	0.27
Seed Coop	SC501	1987/88	3X	Early	W	7.86
Seed Coop	SC601	1989/90	3X	Medium	W	2.58

Source: Seed Coop

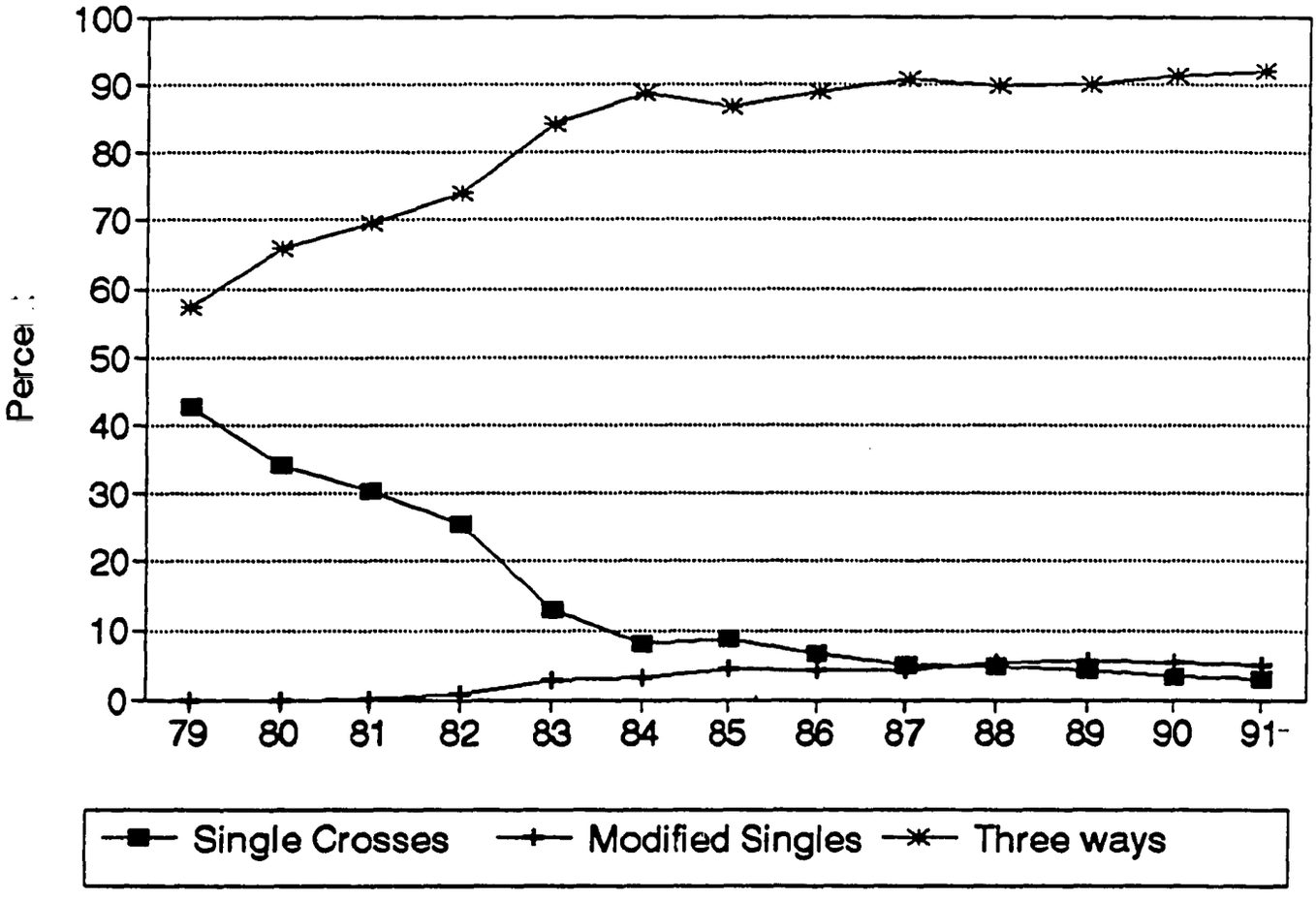
Notes: Two minor varieties sold in 1991/92 are not accounted for here.
SR is South Rhodesia, R is Rhodesia, ZS is Zimbabwe Seed.
SX is single cross, 3X is 3-way, and MSX is Modified SX.
W is white maize, and Y is yellow maize.
Maturity (Early: < 140 days growing cycle; medium: 140-155 days; late: > 155 days).

Exhibit 6.4 shows the increased dominance of 3-ways over single crosses from 1979/80 to 1991/92. In the early 1980s, single crosses and 3-ways were not too far apart in market shares (42.7 and 57.3 percent). Since then, 3-ways have taken off, single crosses have precipitously declined, and modified single crosses, which were introduced in the mid-1980s, now account for 5 percent of the sales. This trend toward the planting of more 3-way cross hybrids is opposite to that of increased use of single crosses in the United States and Europe. Breeders have realized that single crosses generally do better than 3-ways. When predicting the yield of a 3-way cross, one averages the yields of the three parent lines. This means that at least one single cross will be above that average.

Exhibit 6.4

Seed-Coop Sales Of Maize Seed:

Shares By Hybrids, 1979/80 - 1991/92.



Even more surprising is the longevity of these hybrids and the major volume of sales from older hybrids (Exhibit 6.5). Four hybrids (thirty percent of the number) released before 1978 make up 84.5 percent of the total sales. Yet more than half the hybrids sold in 1991/92 by Seed Coop were released since independence. But their 15 percent share of the sales does not reflect their number[7]. The contribution to total sales of hybrids that are over fifteen years old is truly unusual in competitive seed markets, such as the United States.

Also highly unexpected is that the two best-selling hybrids, R201 and R215, which make up over 80 percent of the seed sales of the Seed Coop, are extremely close in genetic constitution makeup. According to knowledgeable sources, the only difference is a single gene, HT, which conditions resistance to Northern Corn Leaf Blight. The germ plasm base of the maize hybrids grown in Zimbabwe is surprisingly limited.

Moreover, there are a few unusual practices, as cultivars are being sold before their official release. Although not officially released by DR&SS, ZS240, an early yellow modified single cross was produced and sold for the first time in the 1991/92 planting season by Seed Coop. Similarly seed of ZS251, a late white modified single cross is being produced by Seed Coop during the 1991/92 planting season for selling in the 1992/93 growing season.

However, the trend in Zimbabwe toward 3-way hybrids may be rational. The area being planted to corn by small scale commercial farmers and communal farmers in NR III, IV and V is now approximately 90 percent of the total. Early white hybrids are needed in most of these areas to avoid the stress that comes from the inherent lower rainfall there, and to match consumer preference for white maize. Three-way cross hybrids may produce more seedling vigor, which could improve stands. Although they are lower yielding in farmers' fields than single crosses, 3-ways have more stable and higher yields in seed production. Therefore, the seed price of 3-ways is lower than that of single crosses. As will be discussed later, lower seed prices for communal farmers may be an important factor.

Although the Seed Coop was given exclusive rights to produce and market corn hybrids developed and released by DR&SS, it initiated its own corn breeding program in 1973. This program is currently well funded, with experienced plant breeders in charge. The first hybrid developed in the program was an early white 3-way, SC501 sold for planting in the 1987/88 planting season. SC601, a medium maturity white 3-way cross hybrid, was released for planting during the 1989/90 growing season. These two hybrids made up over 10 percent of Seed Coop sales volume in the 1991/92 growing season.

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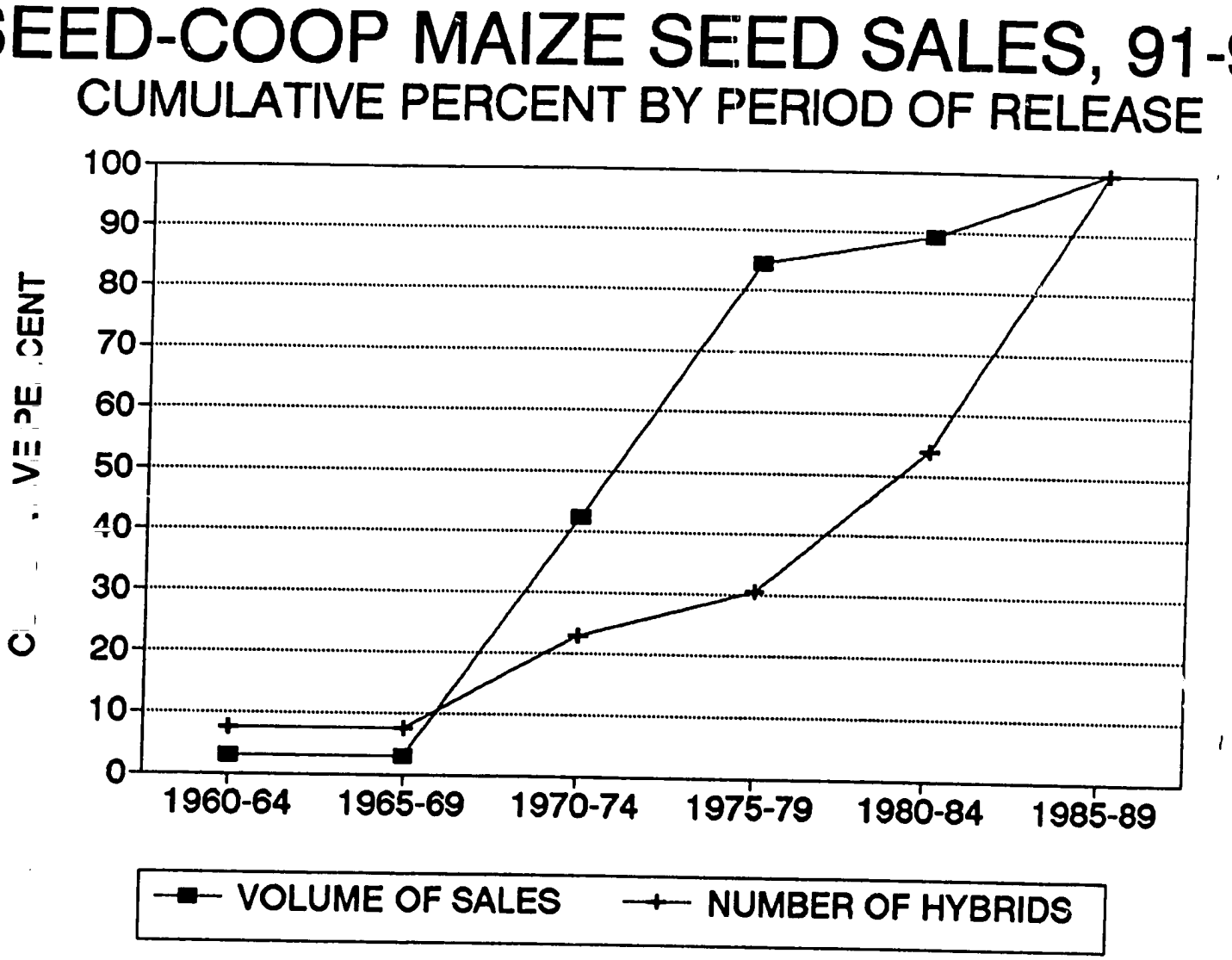
[7] Note that estimates of exhibit 6.4 and 6.5 are based on the 11 hybrids of exhibit 6.3 and the two other minor hybrids sold by Seed Coop in 1991/92.

Exhibit 6.5


SEED-COOP MAIZE SEED SALES, 91-92:
CUMULATIVE PERCENT BY PERIOD OF RELEASE
100
90
80
70
60
50
40
30
20
10
0
1960-64
1965-69
1970-74
1975-79
1980-84
1985-89
VOLUME OF SALES
NUMBER OF HYBRIDS

There are indications that since 1991/92, Seed Coop has entered into a research agreement with DeKalb Hybrids, a US company, to exchange breeding material. This is an interesting and logical agreement, which should prove to be beneficial to both parties in the future.

In 1985, CIMMYT initiated its research program in Zimbabwe, in association with the University of Zimbabwe. CIMMYT maize breeding staff are a well-trained, experienced group of plant breeders. Their mission is to assist national corn-breeding programs in Southern Africa by providing improved sources of germ plasm, including inbred lines, and training to personnel working in the region.

In May 1992, CIMMYT announced that thirty evaluated inbred maize lines from the Zimbabwe program are available upon request to both national breeding programs, as in the past, and now also to private company breeders. This decision follows an announcement made a year ago by the CIMMYT maize program based in Mexico. Previously, provate companies had access to collections and improved segregated populations of maize germ plasm also available to national companies. The May announcement, however, marks the first instance whereby private companies have access to inbred lines of maize.

CIMMYT's decision has great potential for broadening the germ plasm base of maize in Zimbabwe and throughout the world. The incorporation of these selected inbred lines with existing parental lines in both public and private breeding programs should permit a significant improvement of maize hybrids in a rather short period where the material is adapted.

Pioneer Overseas Corporation initiated its maize-breeding program in 1988. It took three years to set up its program for production. Seed of an early yellow hybrid, Pio 3442, was officially approved by the release committee following its inclusion in the advanced DR&SS maize trials. Seed is being produced in 1991/92 for sale in the 1992/93 growing year.

Cargill Zimbabwe (Pvt) Limited initiated its maize breeding program in Zimbabwe in 1991. The company also owns the majority interest in the Malawi Seed Company. Cargill began selling seed of maize hybrids in the 1990/91 growing season. The hybrid sold, CG4141, was acquired from Ciba-Geigy, which had previously tested it in Zimbabwe and had received approval to sell it there. CG4585 and CG4539 acquired from Ciba-Geigy were added to the sales lineup for the 1991/92 growing season.

Private multinational companies are entering the seed market in Zimbabwe and providing competition to the existing supplier, Seed Coop. This increased activity in maize breeding, together with the CIMMYT program, should result in improved hybrids being available for planting in Zimbabwe and the surrounding region. It is interesting and promising that private companies chose to come to Zimbabwe when the maize-growing area has not been expanding and when nearly 100 percent hybrid seed is being used. Obviously, a market for maize hybrids is expected. As we will see later, Pannar, another multinational already sells hybrid seeds developed in South Africa.

6.2.2 Sorghum Breeding

The sorghum breeding program in DR&SS, initiated in 1969, until independence, was concerned with developing red sorghum cultivars adapted to Natural Region II, for the opaque beer industry. Red Swazi A was released from the program. A hybrid DC-75 from South Africa was also approved for growing in Zimbabwe.

Since independence, the DR&SS has shifted its emphasis to breeding white sorghum of suitable quality for processing and adaptability to the communal farmers in NR III, IV, and V. Early maturing cultivars are also desired to increase the chance of avoiding moisture stress. Two improved white sorghum cultivars, SV-1 and SV-2, were released in 1987. These cultivars were developed from material obtained from the ICRISAT program in India. SV-2 is 10 days earlier than SV-1 and has been available to growers since the 1988/89 growing season. SV-1 should be available for farmers to plant in the 1992/93 growing season. The first sorghum hybrid, ZSHI, developed in the program should be released in 1992 for seed bulking by Seed Coop for the growing season 1992/93. It will be used primarily for brewing.

ICRISAT sorghum-breeding program was initiated in 1985 at Matopos. Emphasis is being placed on food-quality white hard seeded cultivars and hybrids adapted to the stress conditions in NR IV and V. No releases have been made to date, although several sorghum hybrids appear promising.

6.2.3 Pearl Millet Breeding

The pearl millet program was started in DR&SS in 1977 and ICRISAT in 1985. Pearl millet can be grown in NR II, III, IV, and V but principally is grown in the drought-stressed NR IV and V. ICRISAT's program is stressing the selection of pearl white grained millet possessing suitable quality for food. DR&SS program released the cultivar, PMV-1, in 1987. However, due to problems associated with increasing seed for farmer use, the cultivar will hopefully be available for planting for the first time in the 1992/93 growing season. If off-season seed production is successful, the cultivar PMV-2 developed by ICRISAT should be available for farmer planting in 1992/93.

6.2.4 Finger Millet Breeding

The finger millet breeding program was started in 1985 by ICRISAT and in 1988 by DR&SS. Finger millet is more suitable for NR II and III. It is tolerant to birds because of its tannin content. Finger millet is used in beer brewing. No cultivars have been released to date from either breeding program.

6.2.5 Irrigated Wheat Breeding

In 1954, the Crop Breeding Institute of DR&SS started its breeding program for irrigated winter (cold season) wheat. Approximately 75 percent of the wheat used in Zimbabwe is

produced locally. However, since the use of wheat in Zimbabwe is restricted by the Government this level of self-sufficiency may be misleading. Several wheat cultivars have been developed or released by the DR&SS breeding program. All involve, to some degree, genetic material obtained from the CIMMYT wheat program in Mexico. The cultivars released are the following:

Angwa	1980	Sengwa	1985
Chiwore	1981	Nata	1989
Rusape	1983	Pote	1991

Wheat breeding was initiated by Seed Coop in 1983. Only one cultivar has been released to date, that is, W170/84.

6.2.6 Rainfed Wheat Breeding

Wheat breeding investigations for rainfed wheat (summer production) were initiated by DR&SS in 1985 and by the University of Zimbabwe in 1989. The higher summer temperatures increase the severity of most rainfed wheat diseases. Rainfed wheat may be of value to farmers in communal areas. No cultivars have been released from either program to date.

6.2.7 Barley Breeding

The barley breeding program of the Crop Breeding Institute of DR&SS is the only one in Zimbabwe. The program was started in 1960 with funds provided for a five-year period from the National Brewery. All barley is grown under irrigation during the winter season under contract to National Breweries, which totally dominates malting barley in Zimbabwe.

Four 2-row malting barley cultivars have been bred and released from the program as well as a recently-released Danish cultivar. These cultivars are the following:

Varieties	Release Date
Diamant	1974
Triumph	1980
Kylo	1981
Rieti	1989
Canut (Danish Variety)	1991

This breeding program is currently suffering from a lack of financial support. In this regard, it shares a common problem with the other breeding programs in the Crop Breeding Institute of DR&SS. A possible source of complete or partial support might be the National Brewing Company, since it is the only buyer of malting barley in Zimbabwe, and the sole beneficiary of the program.

6.3 Seed Production

Because of the Tripartite and Bilateral Agreements, Seed Coop was granted a quasi-monopoly in seed production for controlled cereals in Zimbabwe. Pannar, previously Pioneer South Africa, brought competition to Seed Coop in 1986. Pannar now offers for sale in Zimbabwe five lines (PNR473, PNR6427, PNR6405, PNR6514, and PNR482) developed in South Africa. As mentioned above, Cargill markets three varieties, and Pioneer will start to commercialize its first lines in Zimbabwe in 1992/93.

Cereal seeds are produced by competent and well-equipped seed farmers in Zimbabwe. Seed Coop is owned by some 150 seed growers. There are high barriers to entry into the select club of Seed Coop seed growers. There is a long waiting list and selected growers must pass an evaluation period before they are definitely accepted. Each seed grower in Seed Coop cultivates, processes, and packs its seed. The grower may also store seed. This organization has contributed to the efficiency of Seed Coop.

As new seed houses enter the market, more farmers are offered the chance to grow seed. These private seed houses have no inclination to become farmers and cultivate their own seeds. They have chosen Zimbabwe partly because of the existing pool of expertise in seed growing in the country. New seed houses, for example Cargill and Pioneer, have elected to build their own conditioning plants for better quality control. Seed Coop is also building a new one, but for the export market.

The seed market in Zimbabwe, however, remains limited. New private seed houses intend to take a share of the market away from Seed Coop by offering better products, higher yielding hybrids, or better marketing services. Marketing services rank extremely high in private seed house strategies because of the limited amount of good seed varieties that can be developed. All seed houses in Zimbabwe eye the export market in the region. Zimbabwe has become a strategic location for developing and producing cereal seeds for export in Eastern and Southern Africa.

7. STEWARDSHIP OF CEREAL SEEDS

Stewardship concerns supporting services that promote and distribute technology products to users. Stewardship includes extension, information, training, financing, and distribution efforts. This section examines how public and private institutions handle stewardship of cereal seeds in Zimbabwe.

7.1 Extension

The analysis of the demand for improved seeds (Section 5), showed the key role of stewardship in facilitating the adoption of hybrid maize seed by smallholder farmers in Zimbabwe. The Department of Agricultural Technical and Extension Services (AGRITEX), in the MLARR, has the responsibility for providing extension services to commercial as well as communal farmers in Zimbabwe. AGRITEX is organized into three divisions: field, technical, and irrigation. The Technical Services Division synthesizes and distributes relevant research results for staff in the field services. Seven branches of specialists provide supporting technical services: crop production, planning, irrigation, engineering, agricultural management, training and animal production, and soil and water. For example, the Branch of Agricultural Management Services prepares gross margin budgets to advise farmers on the profitability of various input packages.

AGRITEX employs about 2,000 extension workers, including 1,520 village-level extension workers (World Bank 1991). Since 1980, AGRITEX has shifted its emphasis from commercial to communal farmers. Commercial farmers may still request AGRITEX services. More and more, however, the large-scale commercial farmers rely on their commodity associations, Seed Coop, and the Agricultural Research Trust (ART) farm for technical information. Thus, the more market-oriented farmers rely on private sources of information, while smallholder, poorer farmers rely on government extension services.

AGRITEX's recommendations to communal farmers are derived from those to commercial farmers, according to Rohrbach and Waddington (personal communication). In 1986, the Committee for On-Farm Research and Extension (COFRE) was set up to help bridge the gap between research and extension for communal farmers. COFRE has helped forge stronger ties between research and extension. However, several practices (e.g., manuring, fertilizer applications, seed rate) continue to be recommended without appropriate consideration of farmers' conditions. The farming system research unit set up by DR&SS has stopped its activities for lack of funds. ICRISAT and CIMMYT, and to some extent, Environment Development Activities (ENDA), an NGO, are now engaged in farming system research in the communal areas.

AGRITEX has received substantial funding over the years with increased government spending in agriculture. Extension has relatively more funds, compared to research and

administration, because of the perception that there was a technology already on the shelf (hybrid maize seed) that needed to be transferred to communal farmers.

Private seed houses (Seed Coop, Pioneer, Pannar, and Cargill) are promoting their seeds by running information campaigns in pamphlets, magazines, newspapers, the radio, and reportedly on national television. They also work with AGRITEX extension agents in the field. To showcase their seeds and other agricultural inputs, input suppliers must work in collaboration with AGRITEX to gain access to communal farmers. Although Pannar has not submitted any of its seeds for certification, it has worked in collaboration with AGRITEX in the field to introduce farmers to its seeds. AGRITEX and input suppliers are convinced that farmers can make up their own minds if they have the necessary information on competing inputs or alternative practices.

7.2 Financing

Financing input purchases is one important element of "production packs" promoted by the government of Zimbabwe. For more than 70 years, the Agricultural Finance Corporation (AFC) has provided loans for agricultural inputs and capital equipment primarily to LSCFs. Since independence more and more loans are reaching communal farmers as well. When the GOZ started to reach communal farmers, it guaranteed the loans extended by AFC, since communal and resettlement farmers lacked collateral. Extensive credit loans to communal farmers account for the success of hybrid maize in Zimbabwe. The AFC is launching group lending schemes targeting small-scale commercial farmers. It is also preparing a Development Agricultural Loan, a plan to rehabilitate emergent farmers who will be given loans at concessionary rates. There are complaints, however, that AFC has given relatively more loans to commercial than communal farmers in recent years.

Private seed houses do not foresee a need to finance producers' seed purchases. In part, they believe that the AFC does the job; in part also, financing producers entails too much risk. Rather, private seed houses are concentrating their efforts on establishing distribution networks.

7.3 Distribution Networks

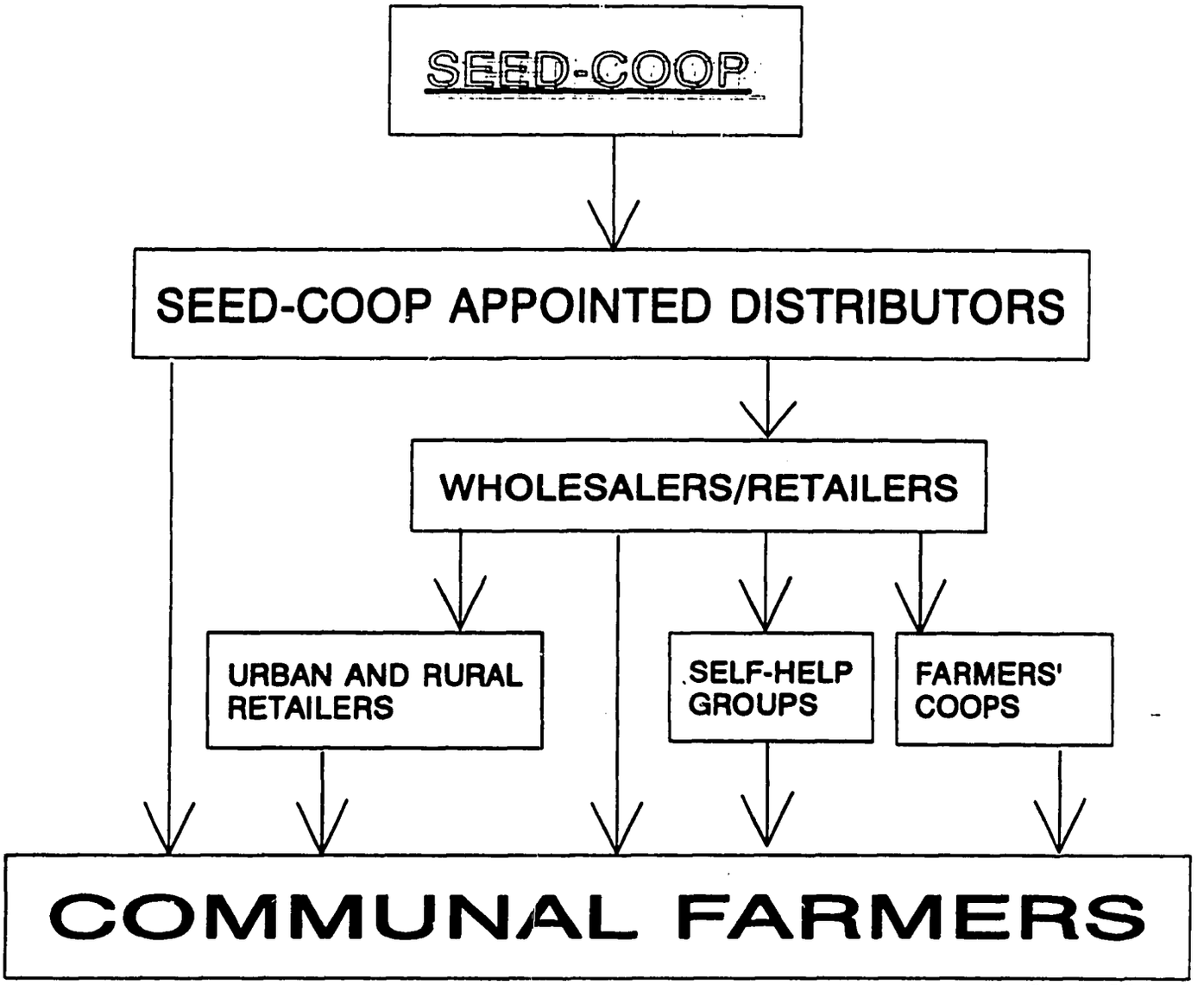
Seed Coop still dominates cereal seed distribution in Zimbabwe. Until recently, it was the sole source of seeds for controlled crops listed in the Tripartite and Bilateral Agreements. Seed Coop has developed a distribution network made up of appointed distributors serving independent wholesalers, retailers, farmers cooperatives, and self-help groups of farmers. In general, large commercial farmers are supplied through one distribution network, and communal farmers through another. LSCFs are supplied directly by seed growers (themselves LSCFs, who are allowed to retain seed for their own use) or by Seed Coop appointed distributors. Communal farmers, on the other hand, are supplied through a more complex and diversified distribution network (see Exhibit 7.1). Seed Coop exerts its control on its appointed distributors. These distributors are left to manage their operations with wholesalers, retailers, and cooperatives.

Other private seed houses plan on more streamlined distribution networks to fit their marketing strategy. Key to this strategy is targeting farmers with an effective demand for their varieties. Although communal farmers cultivate about 90 percent of the maize area, observers note that only about 20 percent of these communal areas account for about 60 percent of the maize marketed (Rohrbach, personal communication; The Insider). Private seed houses have targeted this 20 percent of the communal areas.

Pannar offers large discounts to wholesalers to help establish a reliable distribution network. Cargill is emphasizing quality control, making sure its products are returned for repackaging to relieve wholesalers of unsold stocks and to ensure good germination of its products. Pioneer has yet to sell seed, but is reportedly recruiting wholesalers for its network. Not surprising, however, details of the marketing strategies of seed houses are kept secret.

Exhibit 7.1

SEED-COOP DISTRIBUTION NETWORK FOR CF



Source: Frits-Hansen, 1991.

8. PATTERNS OF COLLABORATION BETWEEN PUBLIC AND PRIVATE SECTORS

The major organizations involved in seed research and production include public organizations (Crop Breeding Institute and Seed Services from the DR&SS, and the University of Zimbabwe); two international agricultural research centers (IARC), CIMMYT and ICRISAT; one nongovernmental organization (NGO), ENDA; indigenous private enterprises (Seed Coop, ART, Export branch of Seed Coop); and foreign private companies, Pannar, Pioneer, and Cargill. Two organizations outside Zimbabwe have played or are playing a significant role: IITA, an IARC, and DeKalb, a private US seed house. To clarify the patterns of collaboration, we distinguish national from foreign private companies, although both types of companies are incorporated in Zimbabwe and thus considered Zimbabwean entities.

The patterns of collaboration identified in Zimbabwe involve exchanging crop breeding materials, conducting research, financing research, and seed services.

8.1 Exchange of Crop Breeding Material

Crop breeding material includes segregating improved germ plasm, inbred (true breeding) lines from which hybrids are produced, and genes for specific desired traits. Plants in a segregating population vary in genetic constitution and are used as sources to develop new inbred lines or to improve their adaptation to local conditions by various breeding techniques (see the section on research and development). New genes may be introduced into a breeding population by crossing lines or "transgenic" transfer with a "gene gun[2]," such as that used in the US, Japan and Europe.

Present exchange of cereal breeding material in Zimbabwe includes population germ plasm, inbred parent lines, and to some extent the introduction of new genes through crosses. The exchange of crop breeding material occurs not only among public institutions, but also from public institutions to the private sector. Exhibit 8.1 shows the present patterns of exchange of cereal breeding material within and between the public and private sectors. National public research institutions are involved in the exchange of crop breeding material with all other institutions, except foreign private companies. Seed Coop, the only national private company involved in cereal breeding, has had exclusive access to DR&SS's breeding material because of the Tripartite Agreement.

Cereal breeding material from CIMMYT and ICRISAT is more often released to national public research institutions than the other way around. CIMMYT maize breeders actively encourage breeders at the Crop Breeding Institute to take CIMMYT material. Zimbabwean corn breeders have been slow in taking advantage of the IARCs for several reasons. First, the young BSc or MSc national plant breeders may be insecure in front of expatriate, senior, PhD breeders at IARCs. Zimbabweans also express a sense of national identity that they fear may be watered down if they interact too closely with well-endowed IARCs. Limited interaction between

DR&SS and IARCs can also be attributed to the breeder's ego, that is the pride that somes from producing a line and creating a new hybrid. Because of its long experience and important maize material, the Crop Breeding Institute also tends to think that it needs CIMMYT less than CIMMYT needs it.

Moreover, the narrow interpretation of the Tripartite Agreement has stifled the exchange of crop breeding material[3] from DR&SS to IARCS, let alone to foreign private enterprises. It has been difficult for CIMMYT to obtain access to corn material from R&SS to conduct comparison trials. Zimbabweans are concerned that a release of their maize material to CIMMYT will violate this agreement. They fear also that CIMMYT could make their material available to neighboring countries with which Zimbabwe wants to maintain its technical and comparative advantage for maize seed production and export. For wheat, sorghum and millet, however, Zimbabwe's cereal breeders have extensively used breeding material from ICRISAT.

The release of crop breeding material from international research institutions to multinational private enterprises is gaining acceptance. Until recently, private seed companies have had access to basic populations, but not inbred lines from IARCs. Now, however, as indicated in Section 6, CIMMYT Mexico has decided to announce (release) advanced genetic material to the public, including private companies. CIMMYT-Zimbabwe will start similar announcements this year. Yet, even before this development, private seed companies have had access to IARCs' material through various arrangements. Through DR&SS, Seed Coop can have access to the material released to national research organizations by the IARCs. Because of the Tripartite Agreement, Seed Coop is sometimes considered a public national organization.

There has been some exchange of plant breeding material within private seed companies in Zimbabwe. Seed Coop is said to have entered a technical agreement with Dekalb, a US company, to exchange genetic material through a licensing arrangement. Such an agreement should benefit the two companies. Seed Coop will enlarge the genetic base of its breeding material in order to compete more effectively with Pioneer and Cargill, now its two main competitors in the national and regional markets for improved seeds. Cargill entered the seed market in Zimbabwe through the outright purchase of three-way hybrids that Ciba-Geigy had developed and was selling in the country. That transaction calls for no further interaction between the two companies.

In summary, the exchange of cereal breeding material follows both informal and formal mechanisms. One such formal mechanisms is the mandate of IARCs, which calls for the centers to make available germplasm free of charge to national pubic research institutes. Another mechanism is the licensing agreement between Seed-Coop and DeKalb. Finally, there is the purchase of Ciba-Geigy's hybrids by Cargill. The exchange of material between DR&SS and the University of Zimbabwe may occur both on a formal and informal basis. Also informal in nature is the access of Seed Coop to DR&SS's germplasm. The Tripartite Agreement between DR&SS and Seed Coop calls for DR&SS to provide lines for Seed Coop to bulk seeds, but it does not call for DR&SS to give genetic material for Seed Coop's own breeding program.

Although the Plant Breeders' Rights provide provisions for licensing of plant material, no organization has taken advantage of this opportunity so far.

Exhibit 8.1:

Current Patterns in the Exchange of Crop Breeding Material Within and Between the Public and Private Sectors in Zimbabwe

FROM / TO	National Public	International Public	National Private	Foreign Private
National Public	DR&SS-UZ UZ-DR&SS	CIMMYT-DR&SS ICRISAT-DR&SS	None	None
International Public	DR&SS-CIMMYT DR&SS-ICRISAT (a)	IITA-CIMMYT (b)	None	None
National Private	DR&SS-SC	CIMMYT-SC (c)	None	DEKALB-SC
Foreign Private	None	CIMMYT-P, Cg (d)	DEKALB-SC	Cg-CARGILL

Notes: SC is Seed Coop, P is Pioneer, and Cg is Cargill

(a) In fact, CIMMYT and ICRISAT have mostly used DR&SS lines for comparison.

(b) Development of resistance to streak virus in maize

(c) Seed Coop has had access to CIMMYT wheat population and maize.

(d) Pioneer and Cargill have access to CIMMYT population possibly through their parent companies in the US.

8.2 Conducting Research

Conducting research includes technology development (in laboratories and nurseries for example), product development, testing for performance evaluation, and testing for certification on station and farmers' fields. In Zimbabwe, several organizations are involved in this research continuum. Besides the organizations identified in the exchange of cereal breeding material, other key institutions include the Agricultural Research Trust (ART), a national private company; ENDA, a nongovernmental organization (NGO); and Pannar, a foreign private enterprise. These three organizations are on the downstream end of seed research; they mainly test for adaptation and demonstrate seed material for extension or for sales.

Exhibit 8.2 shows the current patterns of collaboration within and between public and private sectors. DR&SS, the public national research organization, conducts trials for, or in collaboration with all other organizations, except the University of Zimbabwe. As common in many other African countries, there is no formal collaboration between agricultural research institutions and universities. Informally, though, the two organizations share materials and ideas. Because their trial fields are only five km apart, researchers from the UZ and DR&SS visit one another's trial sites from time to time.

In the past, DR&SS ran trials on its stations for IARCs. More and more, however, because of reduced funds, DR&SS has been asking the IARCs to conduct trials for its program. ICRISAT, for example, runs on-farm trials and on-station trials (in two locations) for DR&SS. This year, for example, when DR&SS was unable to run its winter nurseries, it asked CIMMYT for help.

Seed Coop at its Rattray Arnold Station is conducting 40 to 50 percent of DR&SS's trials. Should this arrangement end, DR&SS breeding program would be further crippled. The Agricultural Research Trust (ART) is a private organization set up by large commercial farmers to conduct research, primarily performance evaluations of material of interest to them. For a fee, ART Farm also runs trials for other organizations, notably private seed houses. When the variety is already on the market, ART will test it free since the trial will provide additional information to farmers.

At present, there is no collaboration in research between international research centers and private seed houses, local or foreign. As will be discussed later, this situation may change in the future as international research centers make plant material available to private seed companies.

Environment Development Activities (ENDA) is a nongovernmental organization, whose one objective is to identify production technology packages for communal farmers. ENDA conducts on-farm research trials in communal areas in collaboration with DR&SS and ICRISAT.

The collaboration between public and private sectors in conducting research follows formal and informal mechanisms. In principle, DR&SS's testing of seeds for performance evaluation (advanced trials) for release and certification follows established rules. There have been complaints, however, that these rules are not clear enough. The number of trials, locations, and data to be collected are not clearly stated. Private seed houses are also complaining about DR&SS's inability to keep up with the load of advanced trials for their varieties. More and more, ART has become the independent organization seed houses are turning to for running trials.

Exhibit 8.2

Current Patterns in Conducting Seed Research Within and Between the Public and Private Sectors in Zimbabwe

DONE BY / FOR	National Public	International Public	NGO	National Private	Foreign Private
National Public	None	CIMMYT-DR&SS ICRISAT-DR&SS	ENDA-DR&SS (a)	SC-DR&SS	None
International Public	DR&SS-CIMMYT DR&SS-ICRISAT	None	None	None	None
Nongovernment Organization	DR&SS-ENDA (a)	ICRISAT-ENDA	None	ART-DR&SS	None
National Private	DR&SS-SC	ICRISAT-SC	None	ART-SC	None
Foreign Private	DR&SS-P, Cg, and Pannar (a)	None	None	ART-Seed Houses (b)	None

Notes: "For" here means that one organization would conduct research for or in collaboration with another one.
SC is Seed Coop, P is Pioneer, and Cg is Cargill.
(a) DR&SS tests (performance evaluation) varieties for all seed houses.
(b) Pioneer uses (rents) ART farm to develop its material.

8.3 Financing Cereal Research

Conducting research involves financial, material and human resources. The exchange of plant breeding materials could also entail financial compensation. This section analyzes the sources of funds available to research organization, and identifies the contribution of the private sector to public research institutions.

8.3.1 Private Enterprises

Private seed houses and research institutions, such as ART, are financed by retained earnings and/or allocations from the mother companies. This is also true for multinationals such as Pioneer International, Cargill, and Pannar. A distinct feature of the local private companies

involved in the seed industry is their cooperative status. Seed Coop and ART are true cooperatives and, though they operate like private corporations, are still run for the benefit of members (seed growers or large commercial farmers). Truly independent cooperatives are unique in Sub-Saharan Africa (excluding South Africa). Seed Coop, however, may be evolving toward a corporation. This development would parallel the pattern that emerged in the United States, which saw private seed houses growing out of independent or federations of seed growers.

ART is supported by large commercial farmers, but the trust also generates funds by charging a fee to run trials for private seed houses. ART charges Z$ 1,500 (US$ 300) for each hybrid tested in 10-12 locations, a somewhat inexpensive service compared to similar tests in other countries, for example the United States. At its Rattray Arnold station, Seed Coop conducts trials for DR&SS free of charge. Performance evaluation tests conducted by DR&SS are not formally charged to seed houses. Services provided by Seed Services are also performed free of charge. Charges for these services would make the public institutions more financially secure.

8.3.2 Public Institutions

Funds allocated to public research institutions, the Crop Breeding Institute, Seed Services, and the University of Zimbabwe have suffered cuts or severe erosion because of inflation. In nominal terms, budgets for the Crop Breeding Institute and Seed Services increased by 18 percent and less than 2 percent, but in real terms, they suffered cuts because inflation (CPI) hovers at 25 or 30 percent per annum.

The University of Zimbabwe. The objective of the Research Council Board at the University of Zimbabwe has been to allocate 2.5 percent of the university's overall budget to research. In 1991, the UZ review committee raised this target to 5 percent. Because of financial difficulties, however, UZ allocated to research Z$ 5 million (US$ 1 million) instead of the Z$ 6.5 million it intended. About Z$ 500,000 goes to crop research.

Contrary to DR&SS, UZ has financial autonomy, which allows it to look for and earmark funds from outside sources, notably international agencies. This year, outside funds earmarked for research (Z$ 15 million) were three times more important than the government's allocation to the UZ (personal communication, Dr. Behbe). UZ encouraged individuals to submit proposals for grants to local and international donors. Most of this initiative, however, has been concentrated in medical and social science research. In 1989/90, the wheat-breeding program (rainfed wheat) received a two-year grant of Z$ 10,000 from the Southern African Center for Cooperation in Agricultural Research (SACAR), an SADCC body. In 1991, it received another Z$15,000. To continue his long-term wheat-breeding program, the wheat breeder intends to go to big commercial farmers for funding. Unfortunately, farmers fear that summer rainfed wheat will act as a source of disease inoculum for winter irrigated wheat, which is of greater value.

Despite its autonomy and a salary scale detached from the general civil service framework, UZ suffers from an inability to recruit new staff members or to retain staff (UZ 1990, p.10). UZ does not offer competitive salaries and benefits compared to other sectors or other countries, for example Botswana and South Africa. In 1990, the vacancy rate in the faculty of agriculture was 20.4 percent. This rate was much higher in commerce (43.8 percent), engineering (41.8 percent), veterinary science (41 percent), and medicine (27 percent). So, the remaining staff have increased teaching loads and reduced time for research.

Department of Research and Specialist Services. DR&SS has been hard hit by reduced funds and staff turnover. The department has lost the best of its breeders to private companies. The veteran corn breeder, with more than 20 years breeding experience, left three years ago to join Seed Coop (as part-time breeder and part-time farmer). He was replaced by a young researcher, fresh from BSc studies. Another experienced corn breeder had already left DR&SS to join Seed Coop, and finally Pioneer International. There is only one PhD breeder at the Crop Breeding Institute, who is also the only breeder with more than 11 years of experience. As illustrated in an earlier section, 11 years is not too much experience given that breeding a variety from scratch takes about 15 years.

In 1990/91, the total allocation to DR&SS was Z$ 25,745,000. The allocation to the Crop Breeding Institute and Seed Services, however, was minuscule, as shown by Exhibit 8.3. This allocation increased by 18.38 percent for the CBI and 1.74 percent for Seed Services. The Zimbabwe dollar devaluation (45 percent) in 1991, however, has been fueling inflation. The situation is becoming desperate, as funds ran out this year to allow the wheat and corn breeders to harvest their trials and prepare for winter nurseries. Corn breeders have asked CIMMYT for help.

Also, Seed Services has notified seed houses that it can no longer send its field inspectors to certify seeds at the seed houses. Private companies are being asked to provide transportation to the inspectors for this task.

Exhibit 8.3

Budget Allocation (Z$) to DR&SS in 1990-1992

Departments	1991/92	1990/91
Crop Breeding Institute	322,000	272,000
Seed Services	175,000	172,000
Total DR&SS	25,745,000	24,495,000

Private seed houses, farmers cooperatives, and marketing boards make voluntary contributions to DR&SS. No royalties are paid to the department for its breeding materials.

Moreover, no fees are charged for services they perform (e.g., trials), nor are sales taxes levied to help the department defray its operation costs.

Seed Coop (the largest contributor to R&SS, when one accounts for the trials conducted at Rattray Arnold) and other private companies express frustration because all monetary contributions they give to DR&SS are pooled in the government treasury, rather than being earmarked for research. Contrary to the University of Zimbabwe, DR&SS was not able to convince the government of its uniqueness so that it could have an autonomous revolving fund.

Most contributions to DR&SS from Seed Coop and other private seed houses are in-kind. Seed Coop conducts an important share of DR&SS's trials on its station, and IARCs are increasingly being requested to do the same. Transportation is provided on occasion, also spare parts and equipment. Funds for training are granted by international research centers. CIMMYT-Mexico trained the corn breeder when he first took the helm at the breeding program. ICRISAT estimates that it spent an equivalent of US$ 5,000 a year in running DR&SS trials, accommodating R&SS researchers and training them. For example, the DR&SS sorghum breeder did his PhD research at ICRISAT's station.

In summary, private enterprises have secure, somewhat well endowed sources of funds to finance cereal seed research and development activities. In addition, the services they receive from public institutions, and sometimes from other private companies as well, are underpriced. In contrast, public research institutions are facing severe budget cuts and loss of staff to private enterprises or brain drain to neighboring countries. Both government and private contributions to DR&SS cereal breeding programs and seed services have been grossly inadequate. Also there is not yet any appropriate, formal mechanism to allow the DR&SS to generate funds or to attract private donations. The situation, however, is slightly better at the UZ, which has been attracting funds from international sources because of its autonomous status.

9. BUSINESS AND REGULATORY ENVIRONMENT

The business and regulatory environment affects the demand for and supply of commodities and technologies. In particular, it may constrain private seed houses' activities. This section examines key elements in the business and regulatory environment that have impact on private seed houses: macroeconomic reforms, price controls, repatriation of profits, and land tenure.

9.1 Economic Structural Adjustment Program

Zimbabwe has embarked on an Economic Structural Adjustment Program (ESAP) to revive its over-regulated and slumping economy. The modest performance of Zimbabwe's economy has been the result of low levels of investment in the productive sectors. This is due to the following investment disincentives: (a) perceived risks associated with unsustainable fiscal deficits and deteriorating macroeconomic stability; (b) stringent foreign exchange regulations that limit access to import of investment and intermediary goods; and (c) relatively high costs of doing business in Zimbabwe because of the over-regulated economy.

Seed houses are concerned that the stability and prosperity that attracted them to Zimbabwe are now declining. As inflation, interest rates, and employment opportunities rise, poverty and insecurity in the cities also increase, making Zimbabwe less attractive than before. Although Zimbabwe appears to have abandoned its socialist stance in favor of more liberalized and pragmatic policies, food security issues are raised with emotion. When local interested parties talk about seed research, they appear on the defensive, though more for maize[4] than other crops, such as wheat and coffee.

9.2 Seed Pricing

Prices of commercial seeds remain controlled in Zimbabwe. With the increased participation of private seed companies in recent years, seed pricing has become a thorny issue in Zimbabwe. Under the Tripartite Agreement signed in 1970, seed prices were negotiated between Seed Coop, the Farmers' Union, and the Ministry of Land and Agriculture. Since 1984, prices of seeds and other agricultural inputs have been administered by the Ministry of Industry and Commerce (MIC), on the grounds that they are retail goods. From 1987 to 1989, prices of seeds and all other commodities and services were frozen by the Ministry of Commerce to fight rampant inflation. In real terms, obviously, seed prices declined these years. Seed Coop has complained that the cost of complying with government regulations has resulted in operating losses.

A seed house that wants to sell seeds in Zimbabwe must submit to the price control authority a "management account" (itemized cost of production) and proposition for a profit margin. After discussion with MIC, which relies on technical advice from the Ministry of Land,

Agriculture and Rural Resettlement (MLARR), the proposed price schedule is accepted or rejected.

Seed Coop submits its costs of production only for SR52, a single hybrid. The government accepts the proposition that 3-ways should be priced at half the level of a single-way hybrid because 3-ways are thought to yield twice as much as single crosses. This way of determining seed prices explains to some extent why Seed Coop maintains SR52 in its product line.

The Ministry of Industry and Commerce has been concerned about the monopoly position enjoyed by Seed Coop because of the Tripartite Agreement. Pannar's entry in 1986 gave the Ministry the opportunity to introduce more competitive pressure on the marketplace. On these grounds, the Ministry accepted the higher prices requested by Pannar. Pannar had pleaded that its seed growers would not merely seek remuneration based on costs of production but rather on the opportunity cost of growing maize seed, which would be based on revenue they could generate by growing cotton. Pannar was willing to be priced out in the marketplace, but not by government fiat. The Ministry, however, uneasy after granting smaller prices to Seed Coop offered to Seed Coop the possibility of increasing its price to the level of Pannar's. According to a price control officer, Seed Coop refused to raise its price, apparently thinking that the Ministry would force Pannar to accept one unique price across the country.

For granting a higher price to Pannar, the GOZ has been accused of inconsistency and unfairness. Not longer is there pan-territorial seed pricing in Zimbabwe. Friis-Hansen (1991) reports that Pannar heavily discounted its prices to attract wholesalers and farmers. Price control officials also contend that Seed Coop has raised its retail price above the official level. No action, however, has been taken. Meanwhile, Cargill has started selling maize seed without being asked by the Ministry of Industry to submit its "management account." In 1991/92, prices per 25 kg of 3-way maize seed for the three seed houses were listed at $39 for Seed Coop, $44 for Cargill, and $58 for Pannar.

In the past, official seed prices were set for a "pocket" of 50 kg. To circumvent the perceived low prices of seeds, Seed Coop offered smaller units (from 25 kg to 500 grams) priced proportionally higher than 50 kg units (Exhibit 9.1). In recent years, as illustrated, the markups of smaller units relative to 50 kg were brought down, mostly when the Ministry insisted that prices of smaller units be prorated on a 50 kg unit basis, but also possibly because of the new competition introduced by Pannar and Cargill, which do not sell 50 kg bags.

9.3 Repatriation of Profits

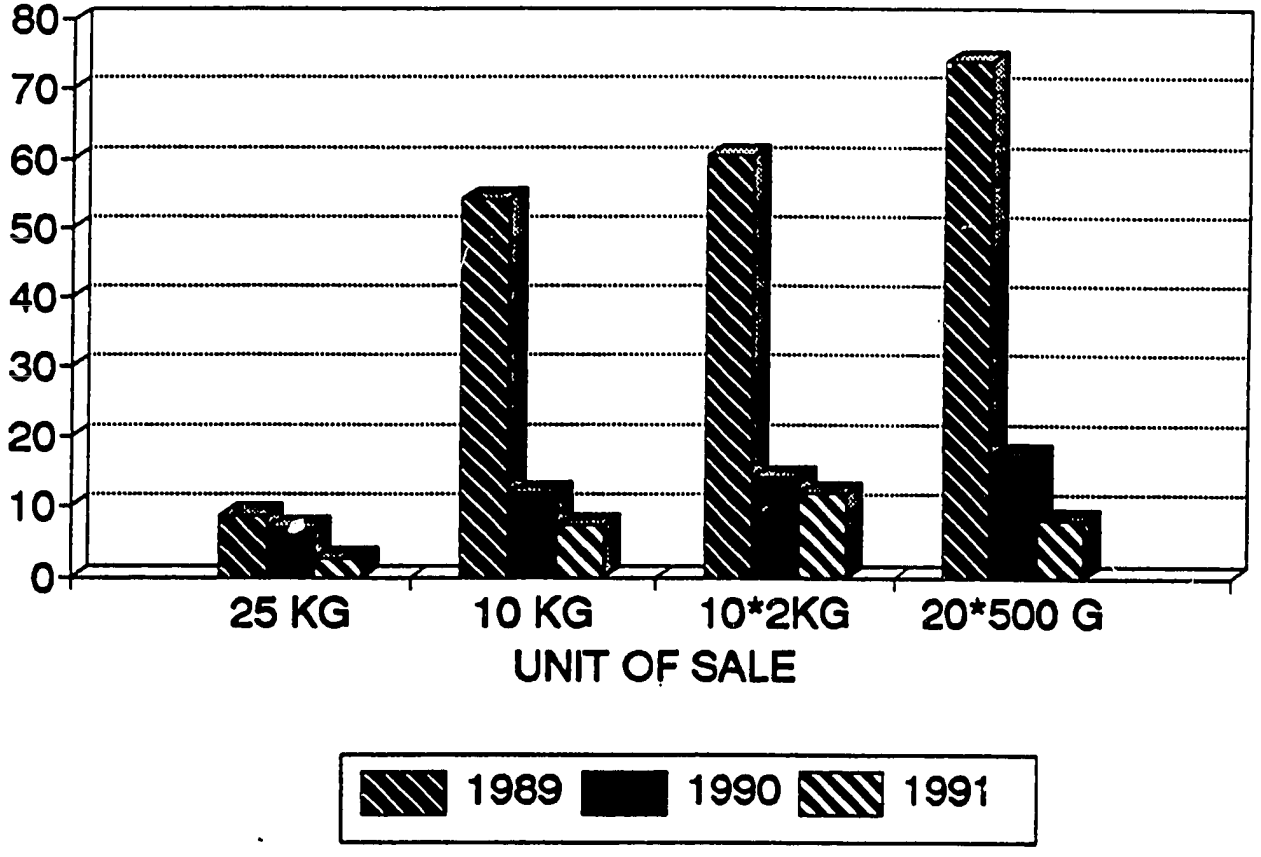
Zimbabwe allows foreign seed houses to repatriate 50 percent of their after-tax profit. Because the corporate tax is 45 percent, foreign seed companies can effectively repatriate 27.5 percent of their before-tax profit. A tax break of up to 20 percent, however, is given to companies that build facilities in "growth" areas. Pioneer and Cargill have taken advantage of this opportunity by building conditioning plants in Zimbabwe.

Exhibit 9.1

MAIZE SEED PRICE MARKUP

SMALLER UNITS RELATIVE TO 50 KG BAGS:

SEED-COOP, 1989/90 - 1991/91



10. INTELLECTUAL PROPERTY RIGHTS

The Plant Breeders Rights Act in Zimbabwe became law in 1973 and regulations pertaining to it were issued in 1974. An official of Seed Services at DR&SS is the administrator of this act. The passage of this act 19 years ago illustrates again the progressiveness of those individuals associated with the seed industry in Zimbabwe. No litigation has occurred to date concerning this act so no statement can be made about its effectiveness. Suffice it to say that such an act is in place, and plant breeders' rights are assigned to improved plant materials when these materials are received.

All cultivars, hybrids, and their component inbred lines developed by the Crop Breeding Institute of DR&SS are covered by plant breeder rights, which are assigned to the government. These improved plant materials are then turned over to Seed Coop without payment of royalties for production and marketing.

An interesting situation could occur if for any reason the Tripartite and the Bipartite agreements were ended by any of the parties involved. As stated earlier, Seed Coop initiated its own breeding program in 1974. Seed Coop has released two hybrids, SC501 in 1987/88 and SC601 in 1989/90. SC501 contains two inbred lines developed by DR&SS and one by Seed Coop. If the agreements were terminated, Seed Coop, as a private seed company would only be able to produce and market one hybrid, SC601, since all other hybrids and component inbred lines that make up their sales line-up would revert to DR&SS. This is unlikely to occur in the near term since Seed Coop would lose its 95 percent share of the Zimbabwe maize seed market. However, Seed Coop is making decisions such as the technical agreement with DeKalb, which suggests that they are moving toward becoming a corporation. If this happens, DR&SS would have to make decisions about seed production, which would have major implications for seed production and marketing in Zimbabwe.

Recently in the United States, most of the hybrid seed corn companies have requested and received plant variety protection rights for their elite proprietary inbred lines. This action occurred several years after the organizations breeding improved cultivars of self-pollinated species had universally requested plant variety protection. Protection, however, is more necessary for self-pollinated species than hybrids. Hybrid seed must be purchased each year by the farmer to realize its genetic potential. A cultivar of a self-pollinated species will breed true and can be replanted by a farmer using harvested seed with no loss of its genetic potential.

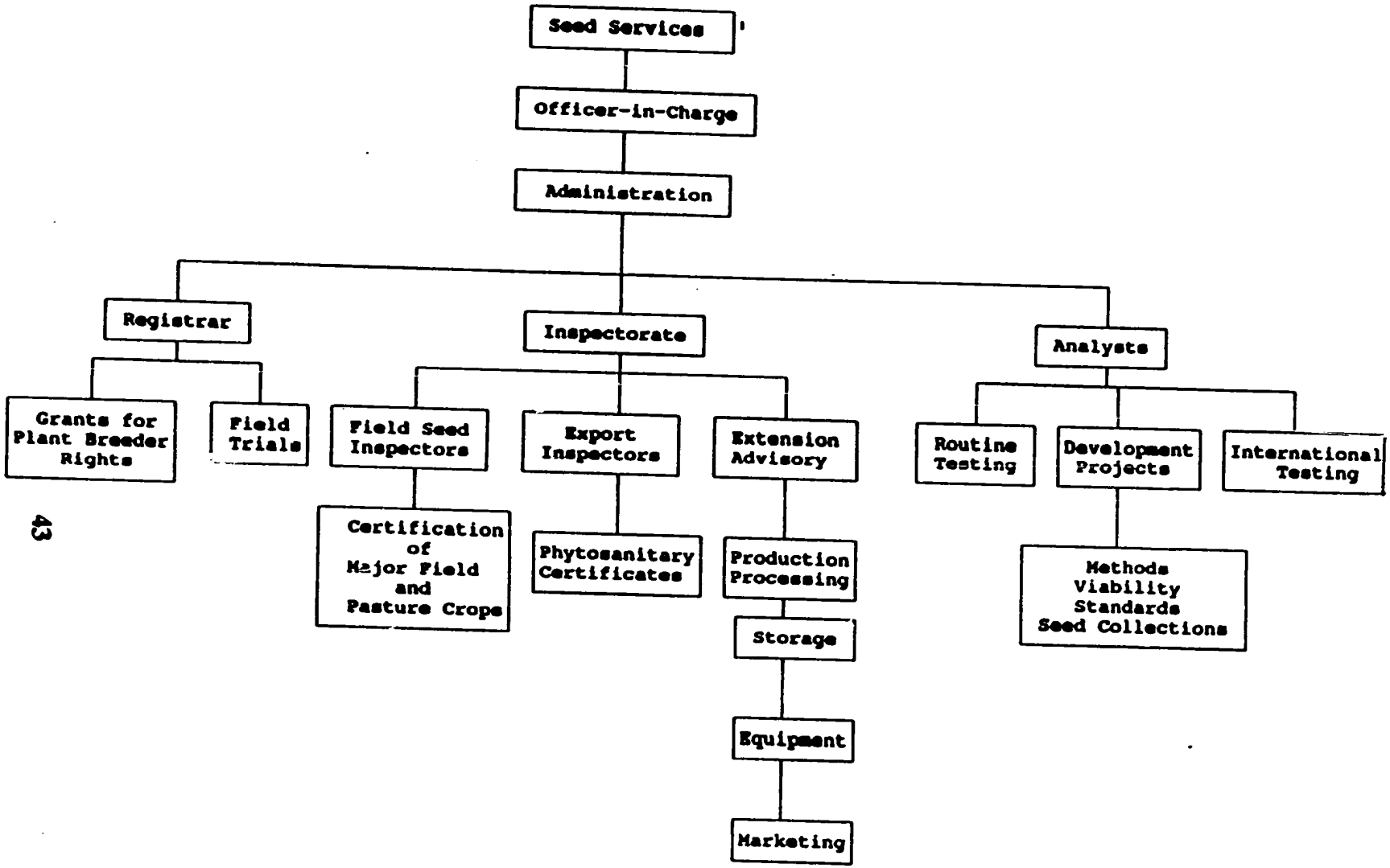
The existence of Plant Breeders Rights in Zimbabwe was not a major factor influencing Pioneer and Cargill to locate their breeding operations in the country. However, it was another tangible advantage in addition to favorable business and climatic factors. In the future, additional legislation protecting patents, trade secrets, etc., may be in order. However, at present this type of added protection is in the developmental stages in the world community. Meanwhile, mutual trust, high business ethics, common sense, and healthy competition within the seed industry will permit more progress than litigation in courts of law.

Seed Services, a component of DR&SS, is responsible for seed certification of major field and pasture crops in Zimbabwe. In addition, it serves as a Registrar for Plant Breeder Rights and possesses a staff of analysts to conduct various laboratory tests on seed samples (see Exhibit 10.1). Laboratory tests of seed include tests for purity, for determination of prohibited weed seed and other crop seed, and for germination.

Seed certification requires that certain minimum standards be fulfilled in the multiplication (bulking) of seed involving both field production and quality of the produced seed as determined by laboratory tests. Field inspections must be made at appropriate times, for example, to ensure that a seed crop is not being produced on land that was planted to the same species the previous season; to inspect for purity (freedom from off-type plants and prohibited weed species); and to ascertain that the proper foundation seed was planted. For hybrid seed production, it is necessary to determine if adequate isolation distances are being used to prevent contamination from foreign wind-blown pollen sources of the same species. In addition, it is necessary in hybrid maize production to make several inspections during the flowering period to ensure that the female parent has been properly detasselled (tassels removed before ear silking) to prevent selfing (inbreeding). Selfing results in nonhybrid plants (inbreds in the hybrid), which reduce yield in the farmer's field. This critical flowering period in maize has a duration of seven to ten days. Several field inspections should be made by Seed Services inspectors during this short period to determine if excessive selfing may have occurred.

The funds for travel for Seed Services are so limited that seed producers must provide transportation for the inspectors to inspect their seed production fields. Two vehicles are available for the travel of seven Seed Services inspectors. These vehicles were donated by the Seed Coop. Additional funding for Seed Services is extremely needed. Part of these funds might be generated by higher fees for services if the Ministry of Finance would permit restricted accounts.

Although seed certification standards are minimum standards, they nevertheless ensure that very high quality seed is supplied to the producer (farmer) of the commercial crop. Historically, seed certification was extremely important in the United States for both self-pollinated species and cross-pollinated species. It still is important for non-hybrid species. However, few, if any, major producers of maize hybrids currently are certifying the seed being sold in the United States. U.S. Farmers have become familiar with the high quality seed merchandized under the various company brand names and accept the brand name in place of the certification. It is extremely important to keep the seed certification system strong at this time to ensure that new seed producers are assisted and monitored if DR&SS and Seed Coop should choose to dissolve their agreements.



1/ Administers Seed Act and Plant Breeder Rights Act.

Exhibit 10.1

PART II: ISSUES AND IMPLICATIONS FOR THE FUTURE

11. EMERGING ISSUES AND IMPLICATIONS FOR THE FUTURE

Several related issues confront the development and use of cereal seeds as the country begins its second decade of independence. These issues concern all aspects of the seed subsector: the demand for cereals products and seeds; public and private sectors' supply, production, and stewardship of cereal seeds; prices and other business regulations; plant breeders' rights and seed certification; and collaboration between public and private sectors.

11.1 The Demand for Cereals and Cereal Seeds

The current drought and resulting food shortages have forcefully brought food security to the forefront of policy issues in Zimbabwe, in contrast to the late 1980s when the country was praised for bringing a sustainable end to hunger. These shortages serve to underscore the dependence of Zimbabwe on white maize and the social and political importance of this staple. Public officials would like to lessen this dependence, by shifting consumer preference away from maize to other local foodstuffs and shifting production away from maize to other crops.

11.1.1 Crop Diversification

In 1987, the GOZ initiated measures aimed at diversifying agriculture[5] away from maize to higher-value crops. This policy was most successful in promoting nontraditional exports such as flowers, fruits, and vegetables. For example, exports of horticultural products have increased steadily from 1989/90 to 1991/92, and will earn Z$ 165 million in 1991/92[6]. This success follows the provision of foreign exchange for imported technology, plant material and equipment, and the rapid development of skills among Zimbabweans. Tobacco, another high-value crop, continues to attract large-scale commercial farmers (LSCF). This season, the number of tobacco producers grew by 19 percent and the area cultivated by 17 percent (The Herald, 9 April 1992, p.5).

The extent to which maize production may decline because of crop diversification is real because the LSCFs that are attracted to these measures have the highest productivity in maize production. For the 1988/89 season, the Agricultural Marketing Authority (AMA, 1991) estimates that although LSCFs cultivated 130,000 ha of the total maize area of 1,160,000 ha, these large maize growers produced 682,000 tons of the total maize production of 1,870,000 tons. Thus the average yield per hectare was 5.25 tons for LSCFs and only 1.15 tons for communal farmers. LSCFs have complained that the lack of incentives[7] in maize production is forcing them to switch from maize to other industrial and horticultural crops and substitute labor for machinery. In the communal areas, also, progressive farmers grow more and more cotton.

These trends, however, are counterbalanced by at least three other elements. First, smallholder farmers cultivate about 90 percent of the maize acreage, which includes more and more marginal areas that often require replanting. Second, Zimbabwe is about to implement a land redistribution scheme. Large tracks of land taken from LSCFs will be distributed to African farmers. Productivity of this land is likely to decline, at least in the short term, since newly settled farmers will be less experienced in management[8] than LSC farmers. Crop mix, however, is also likely to change, that is, less area is expected to be planted in the most management-demanding crops, such as tobacco and cotton, and greater area is expected to be planted in the less management-demanding crops, such as maize. Third, the demand for maize in the SADCC region and East Africa will continue to increase as population grows. Given that these countries are yet to become self-sufficient in maize, they will be importing increased amounts of maize products and maize seed. Therefore, the net effect of these trends is likely to be an expansion of the demand for maize and thus an increased demand for hybrid maize seed in Zimbabwe and abroad.

11.1.2 Consumer Preference

The demand for wheat is increasing in Zimbabwe. The World Bank (1991) is also concerned about the "wheat trap" that Zimbabwe may be falling into because of this increased demand and public subsidies for wheat production. Yet, wheat production should not compete with maize since wheat is an irrigated winter crop, while maize is a summer rainfed crop. Wheat production is also severely constrained by water availability and government subsidies. Moreover, the GOZ is likely to continue some restrictions on wheat imports in the name of national interest and to protect wheat producers, who form a powerful lobby. Therefore, in the future, the increased demand for wheat is unlikely to have major negative consequences on the demand for maize products and hybrid maize seeds.

Public officials, on the other hand, do want communal farmers to shift away from corn to other local foodcrops, such as white sorghum, pearl millet (mhunga), and finger millet (ropoko), which are easier to grow in risky, marginal areas. Authorities are saddled with the question of how to encourage consumers to eat and farmers to grow more sorghum and millet in place of white maize. The question is not only one of consumer preference, but also one of available technologies for producing and processing sorghum and millet.

The lessons from the demand for maize seed by communal farmers in Zimbabwe are similar to lessons from success stories of the green revolution: to promote the adoption of existing technologies (developed in Zimbabwe by a national research organization, and by International Agricultural Research Centers, elsewhere), one needs government economic measures and effective stewardship, including input delivery and credit. To harness the potential demand for a technology not already in place is a different question. Although a few high-yielding sorghum varieties are available in Zimbabwe, much remains to be done to reach the level of maize research.

To sum up, the demand for hybrid maize seed will remain strong in Zimbabwe and throughout Southern and Eastern Africa. Maize remains the staple in a region that is far from self-sufficient. The demand for wheat will also remain strong, but is not likely to have that great an effect on maize. Anecdotal evidence suggests also that the demand for beer is increasing throughout the region and will support an increased demand for barley products and seed. More problematic is how to sustain and develop the potential demand for sorghum and millet products and seeds.

11.2 The Supply of Technology

The trends identified in the situational analysis raised questions about the future direction of the division of labor between public and private sectors, the genetic base of hybrid maize, how to conduct the execution of R&D for marginal areas, and the overall sustainability of public research institutions.

11.2.1 Public/Private Division of Labor

To a large extent, private interests have always dominated the cereal seed industry in Zimbabwe. Starting in the 1930s, large commercial farmers helped initiate crop research in Zimbabwe (then Rhodesia). One Seed Coop breeder interviewed, Caulfield, argues that, given the lack of resources available in that period, resources were best put to use in a focused research program serving a strong, articulated interest. Since that time, there has been a close and effective collaboration between the public sector and the private sector monopoly, formalized in the 1970s by the Tripartite and Bilateral Agreements. Private interests in the seed industry are likely to increase even more with the added participation of private seed houses in Zimbabwe. This participation, however, will differ from cereal to cereal.

Hybrid Maize. Hybrid maize seed production possesses the requisites for attracting the participation of the private sector. Hybrid maize breeding is applied rather than basic research. There is an effective demand for hybrid maize in Zimbabwe and throughout the region. Hybrid maize is an easily appropriable technology because it gives a monopoly to its inventor, since the inbred lines required to produce the hybrid can be kept secret. The inventor is assured of a market because farmers must buy seed every year to get maximum yields, since retained (F_2) seeds lose some 20 to 30 percent of their yield potential (Pardey, Roseboom, and Anderson 1991).

Other factors (economic, technical, and government policies) have attracted multinational seed houses in Zimbabwe. The country is representative of the 4.5 million ha subtropical midaltitude maize production zone[8] that accounts for about 65 percent of the maize area in

[8] CIMMYT (1990, p.11) groups maize production in Eastern and Southern Africa into four zones: lowland tropical (about 18 percent of total area); wet subtropical mid-altitude (49 percent); dry subtropical (approximately 16 percent); and highland (about 16 percent).

Eastern and Southern Africa (CIMMYT, 1990). For expatriates, Zimbabwe offers better living conditions than most other countries in the region. A long tradition of maize breeding and seed production has produced a good pool of skilled researchers and seed farmers. Until recently, Zimbabwe was viewed as an oasis of economic and political stability in the region. To some extent also, the sophisticated regulatory system including the Plant Breeders' Right Act and seed certification and inspection attracted multinational seed houses.

Although they will benefit by having access to breeding material from DR&SS, multinational seed houses have the means to develop, produce, and market hybrid seeds on their own. Thus, research and development of hybrid maize seed have the characteristics of a private good in Zimbabwe. The question in Zimbabwe is no longer "should the private sector play a larger role in developing and transferring hybrid maize seed?" The question is more likely to be "what role should the national public research institutions, DR&SS and, to a lesser extent the University of Zimbabwe, play in maize breeding programs?"

Despite the larger role played by private maize seed houses in Zimbabwe, public research institutions are not likely to end their maize breeding programs. First, Seed Coop would still want public research institutions to maintain basic germ plasm, and even continue independent programs if they can have access to this breeding material. Second, all private seed houses are competing for farmers who have an effective demand for their products. Seed prices are likely to rise in the future (see Section 9) and, though seed cost accounts for relatively little in the cost of maize production, it may be significant for many communal farmers with low yields and therefore low revenue. Exhibits 11.1 and 11.2 show the importance of seed costs to commercial and communal farmers. Seed costs to communal farmers have decreased over the years, mainly because of improved yields. Until these farmers are offered better alternatives in other crops, they will continue to grow maize in risky environments. Thus Zimbabwe is compelled to see that appropriate technologies are available to these farmers.

These considerations and the chain of events in Zimbabwe appear to be shaping the future for a division of labor between the public and private sectors in the development, production, and stewardship of hybrid maize seed. Public research institutions would have two primary responsibilities: first, to maintain maize germplasm and, second, to emphasize the development of hybrid maize for marginal areas. For example, an earlier hybrid maize than the ones available today is required for communal areas in Region IV. Private seed houses would take over most of the hybrid maize breeding and commercial sales. These seed houses would organize their distribution network and information systems, while the state would continue to provide extension services and credit to maize producers.

The elements that bought the success of hybrid maize are not likely to be repeated for sorghum and millet because of the lack of a strongly articulated interest from farmers. Today, the appropriate question is more likely to be "how can public initiatives harness public and

private resources to generate the necessary supply of technology for a potential demand, given that it takes considerable time to breed plant material?"

Sorghum and Millet. Thus far, private seed houses have not engaged in any significant activities in sorghum and millet. The size of the market for commercial sorghum and millet remains limited. Red sorghum and finger millet are used in brewing (industrially) local beer. White sorghum, pearl millet, and finger millet for human consumption must target communal farmers in marginal areas. However, communal farmers with weak effective demand are being bypassed by private seed houses.

Therefore, the payoff to private research remains low in sorghum and millet breeding. In addition, only for hybrid sorghum and millet would private seed houses be interested in any research activity. Open pollinated varieties (OPV) are marginally profitable since producers can retain seeds for two or three years without a significant loss of yield. Here, more than for maize, the public institutions have the primary responsibility for much of the research and development of improved varieties.

Barley and Wheat. The multinational seed houses in Zimbabwe are not interested in developing wheat and barley cultivars since seed can be saved and replanted without loss of performance. The markets for these crops remain small. Finally, these commodity subsectors are dominated by a small group of participants. In wheat, there is the powerful wheat growers association. Barley is dominated by the National Brewery, which buys all barley produced in Zimbabwe. Seed Coop appears to be the primary institution to continue the wheat breeding program, based more and more on CIMMYT germ plasm.

In the early 1960s, the brewery industry helped initiate barley breeding in Zimbabwe, and later funded the training of the actual barley breeder, but its contribution has decreased in recent years. As for barley, while the DR&SS is strapped for funds, it would be logical for brewers to take over the entire breeding program since all the benefits accrue to brewers. There are indications that such a scenario may be implemented. Yet, government officials raise the concern that handing over the barley program to the National Brewery would stifle competition, preventing other brewers to enter the market.

11.2.2 Conducting Research for Marginal Areas

Perhaps the larger debate in technology development regards the breeding of cereals for marginal areas in Zimbabwe. Previous programs have developed materials for the high potential areas (Regions II and III), and then tested their adaptability in more marginal areas (Regions IV and V). Similarly, breeders have used high levels of inputs and management in their selection of materials. Their argument is that the potential of the material needs to be determined first, and its adaptability to poorer environments later. More and more, however, researchers argue that all development work should be conducted in marginal areas, beginning with screening and not just at the stage of intermediate or advanced trials. Stress and diseases that are specific to marginal areas need to be accounted for at all stages. Proponents of farming system research

methods also argue that farmers should be given the opportunity to participate in breeding and developmental programs (Waddington and Kunjeku 1989).

As they concentrate on the crops for the more difficult communal areas where private investment is less likely to occur, public research institutions must conduct more breeding programs in these agroclimatic zones. This would imply a relocation of stations and staff, more funds for research, and changes in the collaboration between public and private sectors.

11.3 Sustainability of Public Research

Appropriate division of labor between public and private institutions may be devised and efficient methods of breeding plant material for marginal areas may be developed, but public research institutions will not implement any of these strategies if actual trends in the levels of public research funding are allowed to continue. However, Structural Adjustment Programs, which promote reduced government spending, are likely to reduce public funds for operations and salaries.

The issue is, how can DR&SS generate funds to supplement government budget allocations? Several proposals are being evaluated by the GOZ and its donor partners. A proposed Agricultural Service Project, sponsored by the World Bank, would create a fund available to public and private research organizations. A national Agricultural Research Fund (ARF), already exists, but government grants are dwindling. The DR&SS would like the ARF to receive, not government grants, but budget allocations voted by Parliament. Such allocations would be hard to cut, whereas government grants can be curtailed at will.

11.4 Prices and Other Regulations

Seed Coop and other private seed houses complain that administrative pricing of cereal seeds does not provide reasonable profit. Compared to most other countries, hybrid maize seed is cheaper in Zimbabwe. It is not clear whether the GOZ will maintain price controls in the future. Economic liberalization programs are likely to lift many price controls. Yet, observers believe that some control on seed prices is likely to be maintained for some time, in the name of food security. Despite price controls, however, the real price of seeds is likely to rise because price authorities have accepted the rationale of pricing seeds at their opportunity cost. Following Pannar, other seed houses are likely to argue that their seed growers want to be compensated based on their next best available farming opportunity, for example, growing cotton or tobacco.

Significant price increases are needed by private seed houses for two main reasons: to provide a large enough margin to wholesalers to maintain an efficient and reliable distribution system, and to generate better profits and retained earnings for future investment in research and development. Seed Coop will tend to gain from price increases since its costs of production appear to be well below those of competing houses. Although it has been noted that the cost of producing 3-ways is likely to be a third, not half, the cost of producing single crosses, Seed

Exhibit 11.1

Maize Seed Cost to Communal Farmers
(% of Gross Revenue) by Type of Hybrid

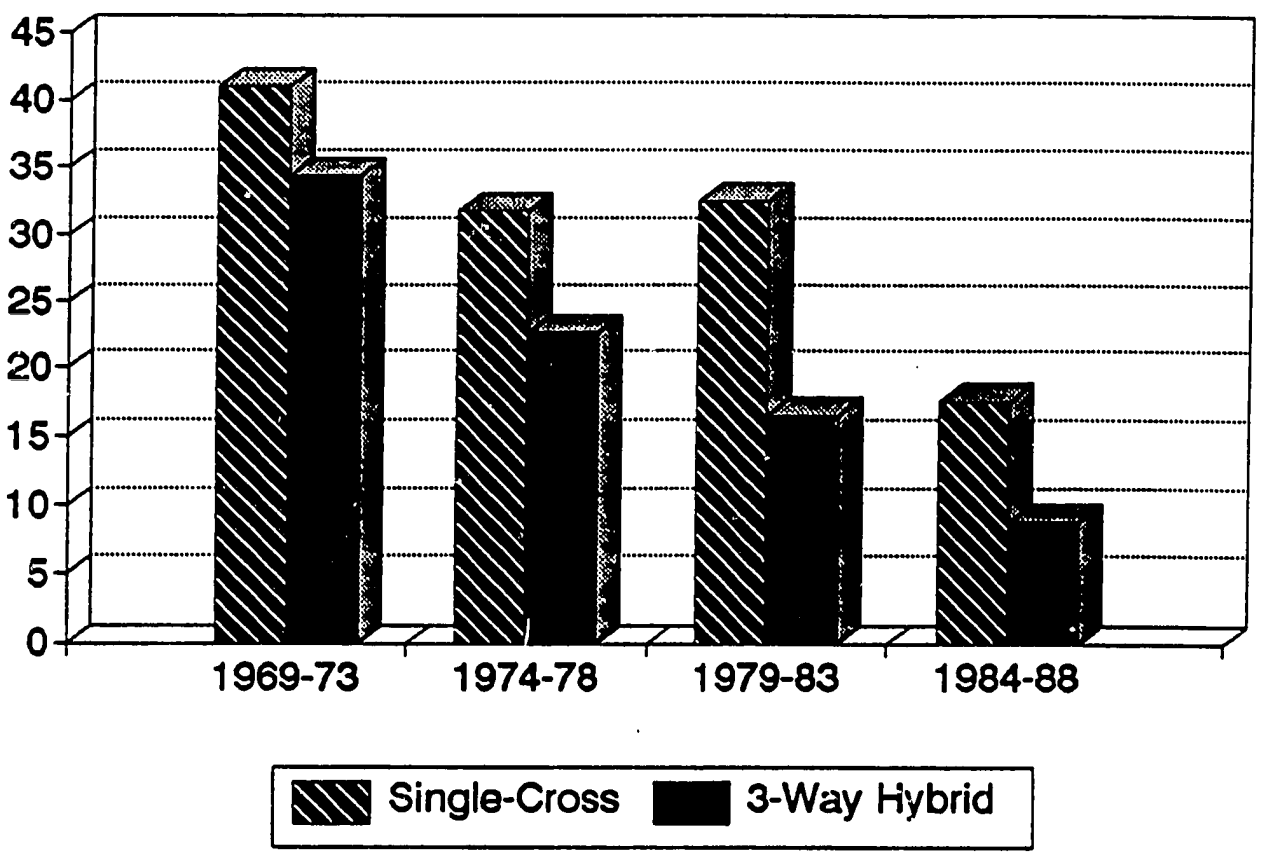
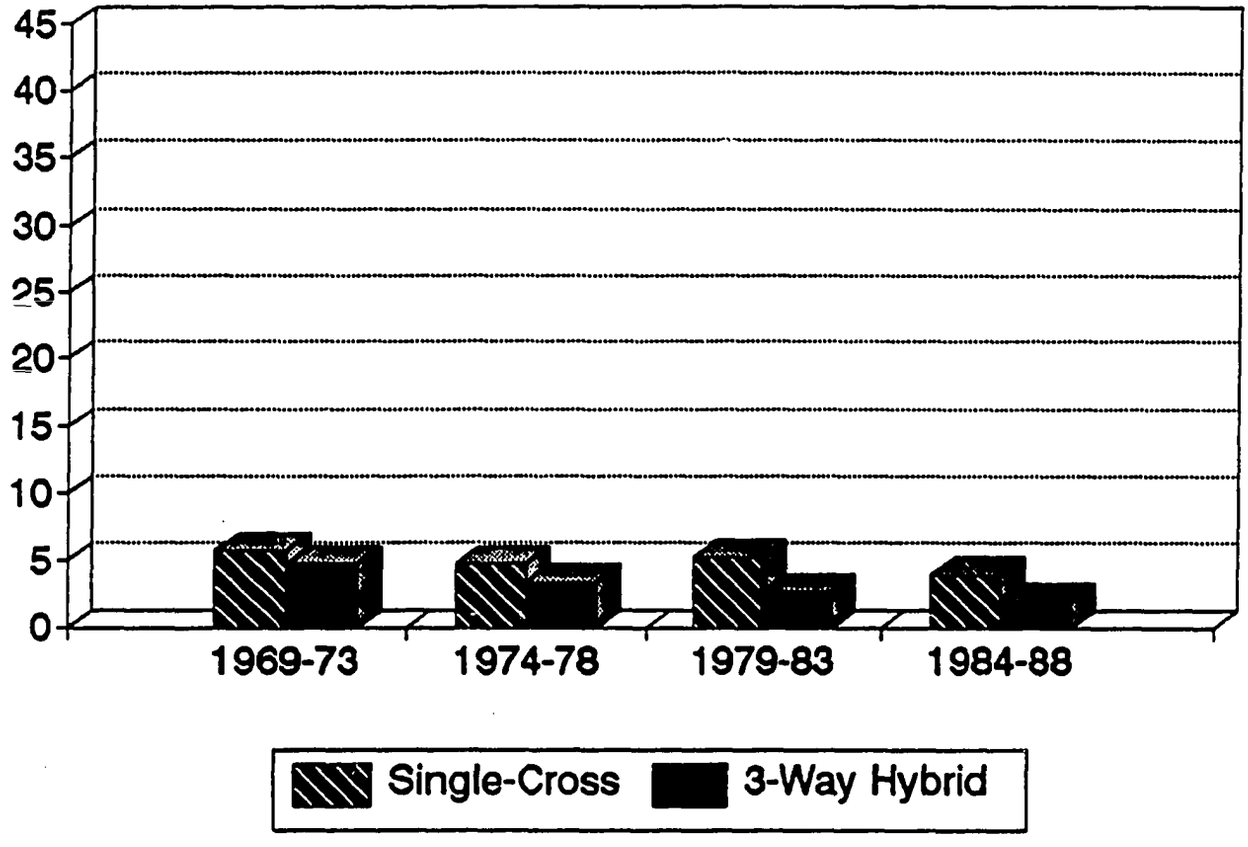


Exhibit 11.2

Maize Seed Cost to LSC Farmers
(% of Gross Revenue) By Type of Hybrid



Coop has survived with prices substantially below its competitors', a testimony to its efficiency and volume of sales.

Zimbabwe recently signed an agreement with Canada to avoid double taxation of individuals and companies with interests in both countries. Officials report that "reasonable" tax rates have been agreed to on withholding taxes (The Herald, 17 April 1992, p.15). This agreement, when observed for all countries, is likely to increase the after-tax profit that multinational seed houses may repatriate. This added flexibility increases the resolve of these multinationals to invest in Zimbabwe.

11.5 Collaboration Between Public and Private Sectors

The increased participation of the private sector in the cereal seed industry is bringing not only more competition, but also changes in the collaboration between public and private sectors.

11.5.1 Seed Coop and DR&SS Agreement

The strong bonds that previously existed between Seed Coop and DR&SS have begun to erode. In building its own breeding programs in maize and wheat, Seed Coop is positioning itself as an independent seed house. When Dr&SS began giving increased attention to communal farmers, commercial farmers and Seed Coop felt left out. At the same time, government authorities were feeling uneasy about Seed Coop's monopoly position. The price increases granted to Pannar indicated that price control authorities wanted at all costs to introduce competition against Seed Coop. The fact that most breeders and other technical staff that left R&SS or other agricultural public services went to Seed Coop may also have raised the level of resentment between Seed Coop and most members of DR&SS. It is revealing that DR&SS breeders have gone to CIMMYT, and not to Seed Coop, for help in operating their winter nurseries. Apparently, more and more, Seed Coop is being perceived by DR&SS as just another private seed house and even sometimes as a competitor. DR&SS has let it be known that the agreement between Seed Coop and DeKalb could nullify the Tripartite and Bilateral agreements it signed with Seed Coop because government plant breeding material given to Seed Coop could be passed in secret to DeKalb.

Several participants of the seed industry believe that the Tripartite and the Bilateral Agreements will be amended. Will they be scrapped? In the near future, scrapping these agreements does not seem likely. The agreement has worked well so far for both parties. Also, Seed Coop cannot sever all its ties with DR&SS because only one line in its 3-way hybrids is proprietary.

If the agreements were to be scrapped, possible options for DR&SS would include: (1) designating one or more groups such as the current marketing cooperatives as the seed-producing unit or units under arrangements similar to those held exclusively now by Seed Coop; (2) releasing hybrids and their component inbred lines on a hybrid by hybrid basis exclusively to one seed producer on a royalty payment basis; or (3) releasing new evaluation-proven inbred

lines to all seed producers in Zimbabwe (both Seed Coop and private companies) to use in the released hybrid combination or in combination with their proprietary (private) inbred lines on a royalty basis.

11.5.2 Public Institutions and Multinational Seed Houses

Plant breeders, regardless of employer, traditionally have been willing and encouraged to share knowledge of breeding methods and program activities with each other. The increasing awareness of intellectual property rights, plant patents, trade secrets, etc., in the United States has restricted somewhat this free exchange of ideas, methods, and program activities among breeders.

National and international public groups may collaborate in seed research during the breeding phase or product development phase. This collaboration, however, is highly unlikely to occur between private sector companies or between private companies and public sector groups. The exception could involve the possible funding by private seed companies of specific research studies by national or international public groups. Private seed companies may provide land and/or labor for off-season breeding nurseries as well. It is highly possible that the National Brewing Company would fund all or part of the barley breeding and sorghum breeding programs of DR&SS. Similarly, the wheat breeding program may be partially funded by milling and baking companies in Zimbabwe.

On the other hand, much more collaboration between the specified groups can be expected to occur in conducting performance evaluation trials of both experimental and commercial hybrids and cultivars of maize, sorghum, and millet. When groups exchange trials to grow at their respective evaluation sites, a superior testing grid results for everyone since more environments are sampled each year. Operation economies occur when a group is evaluating several trial plots at a few large locations rather than many small locations. This results primarily in reducing the expenses related to travel. National and foreign private seed companies will eventually exchange performance evaluation trials as well as conduct trials of special interest for the national and international public breeding groups. The group conducting the trial will not know the identity of the material being evaluated. However, the packaging trial group will be able to visit their trials regardless of where they are grown to make appropriate notes and observations. Following harvest, the data will be returned to the packaging group for analysis and interpretation.

11.5.3 IARCs and Private Seed Houses

CIMMYT will make its inbred lines from the Zimbabwe program available to foreign private companies in May, 1992. In the past Pannar, Pioneer, and Cargill were able to obtain segregating breeding populations and germ plasm collections from CIMMYT. No changes in the exchange of breeding materials are anticipated from national-private or foreign-private groups as shown in Exhibit 8.1 in the situational analysis.

PART III: CONCLUSIONS AND RECOMMENDATIONS

12. CONCLUSIONS

Following are conclusions and lessons which will provide a context to the recommendations.

The demand for seed depends on many factors, not only on consumers' demand for the commodity, but also on the accompanying managerial technology and extension services for producing, storing, and transforming the commodity. One major lesson learned in Zimbabwe is that strong demand for white maize was necessary but not sufficient in itself to develop hybrid maize seed in Zimbabwe. The success story of hybrid seed occurs in two stages. In the first phase, starting in the 1930s, large commercial farmers dominated agriculture, research and government policy agendas, and engineered the development of hybrid maize seeds. After independence, in 1980, the GOZ, with strong political backing, harnessed policies and stewardship to push, in a spectacular way, a technology already available to the masses of communal farmers. The Green Revolution is made of similar success stories. The uniqueness of Zimbabwe is that hybrid maize seed was developed by the national, and not international, research centers as in the Green Revolution.

To achieve similar success in sorghum and millet for marginal areas is proving more difficult. The demand for sorghum products is weaker, production and processing are more labor intensive, and the technology is not quite on-the-shelf. There are, however, promising signs from varieties coming from ICRISAT and DR&SS. Another lesson is that for a private seed industry to develop, governments, with eventual help from donors, have to be involved in the initial research stages and in the establishment of more favorable business climate.

Despite its success, the genetic base of hybrid maize in Zimbabwe is narrow. Two hybrids that make up more than 80 percent of the sales in 1991/92 are closely related, distinct by only one gene. Moreover, the dominance of three-way hybrids runs counter to recent developments in the United States and Europe, where single crosses have proven to be higher yielding.

There are also definite signs of a rapidly-declining performance by the public research institute and seed services in Zimbabwe. Independence saw qualified staff leaving research and extension. Economic crises in recent years have further severely reduced funds to research and seed services. The competition from private seed houses has changed old patterns of collaboration between the national research institute and the private monopoly.

International Research Centers (CIMMYT and ICRISAT) and international seed houses, especially three based in the US (Pioneer, Cargill, and DeKalb to some extent), have a distinct advantage over the DR&SS breeding programs and stimulate the professional growth and development of cooperative projects.

Private seed companies, including Seed Coop, not only have interests in selling seed in Zimbabwe, but also major stakes in increasing sales, and even starting breeding programs in other countries in the Eastern and Southern African Region. With South Africa being accepted into the fold of nations, competition in the seed industry in the region is likely to intensify. The globalization of this industry has major implications in intellectual property rights throughout the region.

13. RECOMMENDATIONS

Several recommendations to improve seed technology development and use may be suggested to decision-makers in Zimbabwe and USAID.

13.1 Crop Breeding

Maize. It is essential that more effort be spent in developing earlier maturing and more drought-tolerant white maize hybrids than R201 and R215 for Natural Regions IV and V. New hybrids, yellow and white, are needed in Natural Regions (NR) II and III as well. Increased resettlement activity in N.R. IIA and B are likely to cause an increase in the area devoted to maize over other crops since it is the basic food in the diet and is so well adapted. In addition, because of the existing shortage of maize for food in Zimbabwe and Southern Africa, food security requires that intensive breeding efforts be continued to maintain the competitive relationship of maize to other crop species in the high-yielding environment of natural regions IIA and B.

In NR IIA, IIB, and III, double cropping systems of winter grown irrigated wheat and maize or sorghum in the summer season should be investigated. Double cropping of these cereals would markedly increase the production per unit area in these productive regions.

Sorghum and Millet. The limited rainfall plus its erratic distribution in much of NR IV & V strongly suggests that communal farmers should restrict their plantings of maize in favor of sorghum and pearl millet to ensure more stability in food supply. As strategies are designed to breed improved seeds of sorghum and millet, ways must be found to boost the demand for these commodities. Blends of 80 percent wheat to 20 percent white sorghum, which have been determined to be acceptable in research tasting panels, will increase the demand for white sorghum. Research must also be undertaken to reduce labor intensiveness of sorghum and millet processing to the level of maize. If sorghum and/or pearl millet is accepted, financial support for the purchase of mills would be essential. Comparison of several hybrids or cultivars of each species in the same trial is required in the drought-stress area under typical communal farmer conditions to evaluate their economic potential, contribution to a stable food supply, and acceptance by consumers.

Location of Research Stations. A system for evaluating experimental hybrid performance under an adequate range of environmental conditions representative of Zimbabwe is a necessity. Presently DR&SS is evaluating its hybrids and several advanced hybrids from Seed Coop and Pioneer at several locations predominately located in NR IIA, IIB and III. Evaluation trials in NR IV and V, where 90 percent of the corn hectarage is currently located, were discontinued several years ago for lack of funds. More testing locations per year will reduce the number of years required to sample adequately the range of environments present in Zimbabwe and permit faster and more aggressive release of new hybrids.

13.2 Conducting and Financing Research Trials

Additional funds are urgently needed by the Plant Breeding Institute at DR&SS to ensure the continuing quality of research. Plant breeding requires a long-term commitment. If this need is not met, then priorities must be established and certain breeding programs ended temporarily or permanently to ensure sufficient funding for those selected.

Because of the critical shortage of funds in the Plant Science Institute, DR&SS, it does not appear likely that adequate trials can be funded at the government's expense. Now, since the Ministry of Finance does not permit restricted funds in the Crop Breeding Institute, the charging of fees to private companies is not a valid solution. It would be logical for the advanced experimental hybrids from DR&SS, Seed Coop, and private companies to be included, for a fee, along with the commercial varieties in the trials currently being evaluated by the Agricultural Research Trust (ART). To ensure adequate evaluation locations in NR IV and V, these same hybrids should be evaluated in trials conducted by the Zimbabwe Farmers Union. If the ZFU lacks adequate financial resources, can matching funds be obtained from AGRITEX or direct from USAID, at least for an initial test period?

The most fundamental change required for R&SS to generate funds is to grant it a special status, similar to the one enjoyed by the University of Zimbabwe. Financial autonomy will allow the DR&SS to provide services at cost and keep the proceeds for its programs. If its staff could also be taken off the general civil service salary schedule they would receive better compensation to stay with the department. Experience is important to ensure research excellence, and success depends on career longevity of key professional personnel.

13.3 Strengthening Seed Services

Certification is currently extremely important to the farmers of Zimbabwe to ensure a source of high-quality seed products for planting. Present funding of this activity by the government is inadequate to ensure the quality of certified seed because of the lack of timely inspections. This does not imply that high quality seed is not being produced today. It does imply that the documentation required to ensure continued high-quality production is inadequate. This activity needs to remain viable so that new producers of seed can be introduced to the necessary certification procedures and regulations if the Tripartite and Bilateral Agreements existing between Seed Coop and DR&SS are canceled.

DR&SS needs to consider implementing a two-track system. One track would consist of strengthening the present system involving the Release Committee, seed certification and Plant Breeders' Rights. The second would involve the production of standard seed (non-certified) with or without Plant Breeders' Rights.

Under this system, data from the ART and ZFU trials would be released to the public. For those groups wishing to certify and/or to apply for Plant Breeders' Rights, these data would be evaluated by the DR&SS Release Committee. We believe that this committee should be

formalized and restructured to include members from the private seed companies doing business in Zimbabwe when their plant species are involved.

The Release Committee of DR&SS would not be involved in cultivar or hybrid releases from private seed companies if certification is not requested. Private seed companies could request Plant Breeders' Rights for noncertified releases by applying to Seed Services, DR&SS, if they chose, since Plant Breeders' Rights and certification are separate entities and are not tied together.

13.4 Promoting Greater Participation of Private Seed Houses

Competition among private seed companies is expected to shorten the effective life of hybrids and greatly expand the current extremely narrow germ plasm base of hybrids planted in Zimbabwe. Participation of private seed companies may be facilitated in several ways.

Exchange of Crop Breeding Materials. The actual pattern of exchanging crop breeding material under the Tripartite and Bilateral Agreements could be changed to broaden the genetic base of seeds in Zimbabwe. If the present agreements were modified, inbred lines of the hybrid cereals, especially maize, but also sorghum and millet, could be released on a paid royalty basis to private companies, as well as to Seed Coop, to combine with their own elite proprietary lines. Production of specific hybrids released by DR&SS may well continue to be restricted to Seed Coop without payment of royalties as under the present plan. The Ministry of Finance would, however, have to change its present position relative to restricted accounts to make the payment of royalties attractive to the Plant Breeding Institute of DR&SS.

The multiplication of self-pollinated cereal cultivars of wheat, barley, sorghum, pearl and finger millet may continue through the Seed Coop. However, if Seed Coop chooses to become a truly private company, then cultivars of these species will be produced by other seed producers under certification. Since the National Brewing Company is the only purchaser and user of barley in Zimbabwe, they may choose to increase the barley cultivars with or without payment of royalties to DR&SS.

Business Environment and Policies. Government policies for controlling the price of seed and the price paid to producers for the commercial crop must be examined and made more flexible or eliminated. Getting the GOZ to further liberalize prices in the near future is politically unfeasible because of the drought and its likely long-lasting effects. The ESAP, however, should continue to press for such measures. Increased competition among seed producers will not only improve hybrid performance but will also modify and improve the marketing process for getting seed to farmers. Programs designed to improve customer satisfaction, build loyalty to a seed supplier, and encourage repeat sales will need to be innovative and positive to succeed.

IPR. Private seed companies are not only interested in selling seed in Zimbabwe but also have a major interest in increasing sales in other countries in the Southern African Region. This

effort could be strengthened if countries other than Zimbabwe and the Union of South Africa adopted Plant Breeders' Rights or some such form of protection. The need for an enhanced form of intellectual property rights in Zimbabwe is dependent on the acceptance by countries in the region of the same form of intellectual property rights.

13.5 Recommendations to USAID

USAID, either locally or regionally, can play a significant role in implementing the specific recommendations that follow:

Provide Long-Term Commitment to Support Research by Public Research Organizations. A long-term commitment must be made to plant breeding programs for crops that are strategic for food security but for which the private sector sees no profit in developing seeds. Research on these crops are the exclusive domain of public institutions until products can be appropriated by private companies. Given that it takes 10-15 years to develop new improved varieties, it is essential that USAID's commitment in support of research for such crops should continue for that length of time. USAID already funds training and research at International Research Centers such as ICRISAT and CIMMYT in such a manner. Several other specific recommendations suggested in this section would also contribute to this goal.

Promote Exchange of Breeding Material With US Public Institutions. The genetic stock of Zimbabwe's white hybrid maize (Hickory King) was acquired in the 1930s from the United States. No major additions have occurred since. One obvious reason for this is the success of Zimbabwe's hybrid maize seeds derived from these populations. Another reason is that the sanctions against the former rebel colony have significantly slowed the exchange of breeding material between the United States and Zimbabwe. In part also, white maize has lost ground to yellow maize in the United States. Yet there still exists excellent population materials from several public universities in the United States. Maize breeders in Zimbabwe have expressed the need for such populations, and USAID can contribute significantly to increasing the flow of materials from U.S. universities to Zimbabwe's plant breeders. Similarly, more sorghum breeding materials from the United States can be made available to Zimbabwe. USAID can fund selected U.S. public universities to make such breeding materials available to Zimbabwe.

Enhance the Sustainability of the National Public Research Institution. For many years DR&SS has requested a more autonomous department that could generate revenues and fund a significant share of its research activities. The University of Zimbabwe has been granted such a status but DR&SS has not, on the grounds that many other services would ask for similar privileges. In collaboration with other donors, USAID could use Non-Project Assistance (NPA) programs as leverage to expedite the GOZ's decision regarding such a proposal. Given dwindling government revenues, some cost recovery and revenue generation is needed for DR&SS's sustainability. Feasibility studies and regulatory measures will be needed to allow the department to charge royalties or fees for services rendered to clients.

Promote Regional Standards in IPR and Contract Enforcement. U.S. seed companies in Zimbabwe have major stakes in the regional markets of Eastern and Southern Africa. Common standards in IPR, seed certification and contract enforcement in the region would significantly reduce transaction costs and enhance the profitability of firms. USAID can play a significant role in helping countries other than Zimbabwe and South Africa adopt Plant Breeders' Rights or similar forms of protection. Mission or USAID-regional NPA programs can be used as leverage to entice countries in the region to standardize their IPRs.

Promote an Understanding of the Benefits of Public/Private Sector Cooperation. The world's leading seed company (Pioneer), two other major US seed houses (Cargill and Dekalb), and the leading South African seed company (Pannar) have erected formidable, competitive market barriers of entry to any other international seed company in Zimbabwe. Northrup King and I.C.I. would be the only logical additions. Seed Coop, the private national company, still dominates the seed market in Zimbabwe. These large companies do not need any direct USAID assistance to develop. However, these large companies do need a supply of well-trained plant researchers from Zimbabwe and a group of people concerned and involved with the seed industry to be exposed to and to become knowledgeable of the private seed industry in the United States. This group should include regulating and DR&SS government officials, university personnel, influential large-scale and communal farmers and representatives from agricultural businesses. USAID should implement and fund such a study group to visit the United States and observe first-hand the public and private sectors of the seed industry. This exposure is important to create a trust and understanding of the benefits of a private seed industry. The building of India's private seed industry started by a similar exposure of Indian participants to the United States, recalls Dr. Lee House of SADCC-ICRISAT. This study group plan may eventually stimulate other private sector seed activity in Zimbabwe in crops other than maize.

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APPENDIX A

Overview of the Fundamentals of Breeding Cereals

Sorghum, pearl millet, finger millet, wheat and barley are self-pollinated species. In these species, both the male (stamen) and female (ovary) structures are contained in the same flower. Pollen grains, which form in the anthers of the stamen, fertilize the ovules, which form in the ovary within the same flower of an individual plant. When breeding self-pollinated species, an initial cross must be made between the two selected parents. The breeder must first remove the stamens (the male parts) from each flower of the designated female parent before the pollen grains mature and cover the head with a protective transparent bag. Pollen is then taken from the male parent and placed on the emasculated flowers of the female parent and recovered.

The harvested seed from the female parent is designated as F1 seed. The F1 seed is then planted, producing F1 plants from which F2 generation seed is produced. Sufficient F2 seed must be produced so that a large population of F2 plants can be grown. Generally a population of 5,000 to 10,000 plants is grown since this generation has the maximum amount of plant to plant variability with each plant expected to have a different genotype (genetic constitution). Selection for the desired combination of plant traits is made using proper screening techniques. Plants selected have been naturally self-pollinated and are threshed on an individual plant basis. Seed of each selected plant is then grown in an individual row the next year and plant selections made. After 3 or 4 generations of selection, the plants within a row become homozygous (uniform genetic constitution) and are bulked for replicated trials to evaluate performance. The potential cultivars are evaluated at multiple sites over a period of 2 to 3 years to determine their agronomic worth under a range of different environmental conditions. If a cultivar performs well in its area of intended use it is increased and released to farmers for commercial production.

Although sorghum is a self-pollinated species, hybrids can be made using a male sterile cytoplasm-fertility restoration system. The male sterile cytoplasm, when incorporated into the female parent, prevents the formation of functional pollen in the anthers of the flowers when pollen restoring genetic factors are not present. Pollen-restoring genetic factors must be present or be introduced into the male parent of the hybrid so that functional pollen will be present in farmers' field. Hybrid sorghum seed is produced in fields isolated by distance or time of planting from a contaminating source of foreign sorghum pollen to ensure genetic purity. Female and male parents are planted in alternating blocks of rows to ensure that pollen from the male parent pollinates the male sterilized flowers of the female parent. Only seed from the female parent rows is harvested, dried, conditioned, and packaged for sale to farmers.

Maize, on the other hand, is a cross-pollinated species possessing two incomplete flowers, the tassel (male) and ear (female). In nature, the silks of one plant receive wind blown pollen from the tassel of the plants in the field. Each ovule on an ear connects to a different silk on the cob, which develops into a kernel after a pollen grain fertilizes it.

In maize breeding, all pollinations are made by hand using paper bags to exclude pollen from the developing ear, and to collect pollen from the tassel. All developing ears on selected plants to be used as female parents (seed parents) must be covered by an ear bag before the emergence of silk to prevent contamination by foreign pollen. Any exposed silks are receptive and can be pollinated by any foreign wind-blown pollen present in the field resulting in unknown parentage. The tassels of the desired male parent are covered by a tassel bag, which is closed by using a paper clip or staple the afternoon before the pollination is made. Pollen is released from the mature anthers present in the tassel by mid-morning the following day and collects in the tassel bag. The bag containing the pollen is removed and used to pollinate the silks of an ear-bag protected ear shoot. Following the application of pollen to the silks, the ear shoot is immediately covered with the tassel bag and stapled to the stalk, which remains until harvest. This procedure prevents contamination from an undesired pollen source. The term self-pollination is used when the pollen source and the ear shoot are on the same plant. A cross pollination involves the use of pollen from one unrelated plant to pollinate the ear of a second plant.

Inbred lines or parent lines of maize are developed by successive generations of selfing (inbreeding) accompanied by selection of desired traits of individual plants from appropriate breeding populations. Frequently an F2 generation population resulting from a cross of two existing superior inbred lines is used as a breeding source. In other cases, segregating populations developed by various character enhancement systems to form elite sources of germ plasm are used. Four or five generations of selfing are most frequently used before making new experimental crosses for evaluation to ensure that the inbred lines are stable and can be used indefinitely to remake the identical hybrid being tested. The experimental crosses are evaluated at multiple sites for 2 to 3 years to determine their agronomic worth under a range of environmental conditions. If a hybrid does well in its areas of intended use, it is produced in fields isolated from other sources of contaminating corn pollen, conditioned, packaged, and sold to farmers.

1. In the 1990/91 marketing season, opening maize stocks at the Grain Marketing Board (GMB) stood at 1,165,00 tons. In June or July 1992, though, it became clear that maize production and closing stocks could not carry the country through the following season (The Herald, 11 April 1992).

2. Cornell University developed the "gene gun" and licensed it to Dupont Company. The purpose of the "gene gun" is to transfer genes with desired traits (e.g., resistance to virus) from one plant to another. A "gene gun" is currently being used at the University of Zimbabwe to develop "transgenic" tobacco, cassava, yams, sweet potatoes, irish potatoes, and coffee ("UZ findings to boost crop yields," The Sunday Mail, 12 April 1992, 2). The University reports that this technique can increase crop yields by as much as 50 percent.

3. Lee House, director of SADCC-ICRISAT, pleaded for an open and free exchange of germplasm at the first regional workshop on Plant Genetic Resource Management, realizing that "there has been gradual increased feeling that germplasm was a national property that should not

be made freely available to others. [Yet,] germplasm collections are a necessary part of crop improvement programs, ... and free exchange should be encouraged as it could benefit all countries in the region." (Chronicle, 4 April 1992).

4. On April 16, 1992 (p.11), the main daily, The Herald, in reporting that "Western pharmaceutical and seed companies rip off Third World" appears to give credence to Henk Hobbelink, a Dutch agronomist, who was making this accusation in London. Mr. Hobbelink contends that western biologists incorporate genetic plant material taken from Third World countries and sell back improved genes to these countries. Oxfam's Dorothy Myers, reports The Herald, also contends that countries seeking support for patented new life forms created through genetic engineering would make it difficult for Third World farmers to freely sow seed containing patented genetic material that had originally been derived from their own countries.

5. In the wake of the recent food (maize) shortages, the promoter of diversification (then minister of agriculture) was called upon to respond to criticism about this strategy ("Mahachi Defends Move to Diversify Crop Production," The Herald, 16 April 1992, 1).

6. The Horticultural Promotion Council estimates that 3,722 tons of flowers and 4,215 tons of fruits and vegetables worth Z$ 90 million and Z$ 75 million will be exported to the European and East Asian markets during the 1991/92 season. The council estimates that at least 10,258 tons of fruits, vegetables, and flowers will be exported next season ("Horticultural Products To Earn $165m in Forex," The Herald, 30 March 1992, 1).

7. In its quarterly guide to the economy, the First Merchant Bank reports that the greater interest in tobacco stems from "partly from the shift away from the production of controlled crops, particularly maize and cotton, as a result of Governments's unwillingness to allow producer price increases at rates comparable to the rate of increase in producer costs," ("Drought Deepens Concern Over State of Economy," The Herald, 9 April 1992, 5).

8. The GOZ has adopted the Land Acquisition Bill "to redress the land discrepancy that has been prevalent in the country for over a century. The government could not do anything until now because it was bound by the tendons of the Lancaster House Constitution for 10 years." ("Land Bill to Redress Imbalances -- Nkomo," The Herald, 30 March 1992, 6). The Indigenous Commercial Farmers' Association (ICFA), which represents black large-scale commercial farmers mentioned that when they were resettled in white-dominated sectors in the 1980s, some of them failed to fully exploit the potential of their farms mostly because of the failure of the government to give them adequate support. To avoid the same mistake, the association suggests that would-be settlers be screened and those retained given adequate on-the-farm training before being given the land to cultivate. The ICFA supported the Commercial Farmers' Union (CFU), which represents large-scale white commercial farmers, in opposing designation under the Land Acquisition Bill. It appears, however, that the government is adamant about designation. ("State Urged to Settle Only Qualified Farmers," The Herald, 26 March 1992, 3).

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