ZIMBABWE'S AGRICULTURAL REVOLUTION REVISITED

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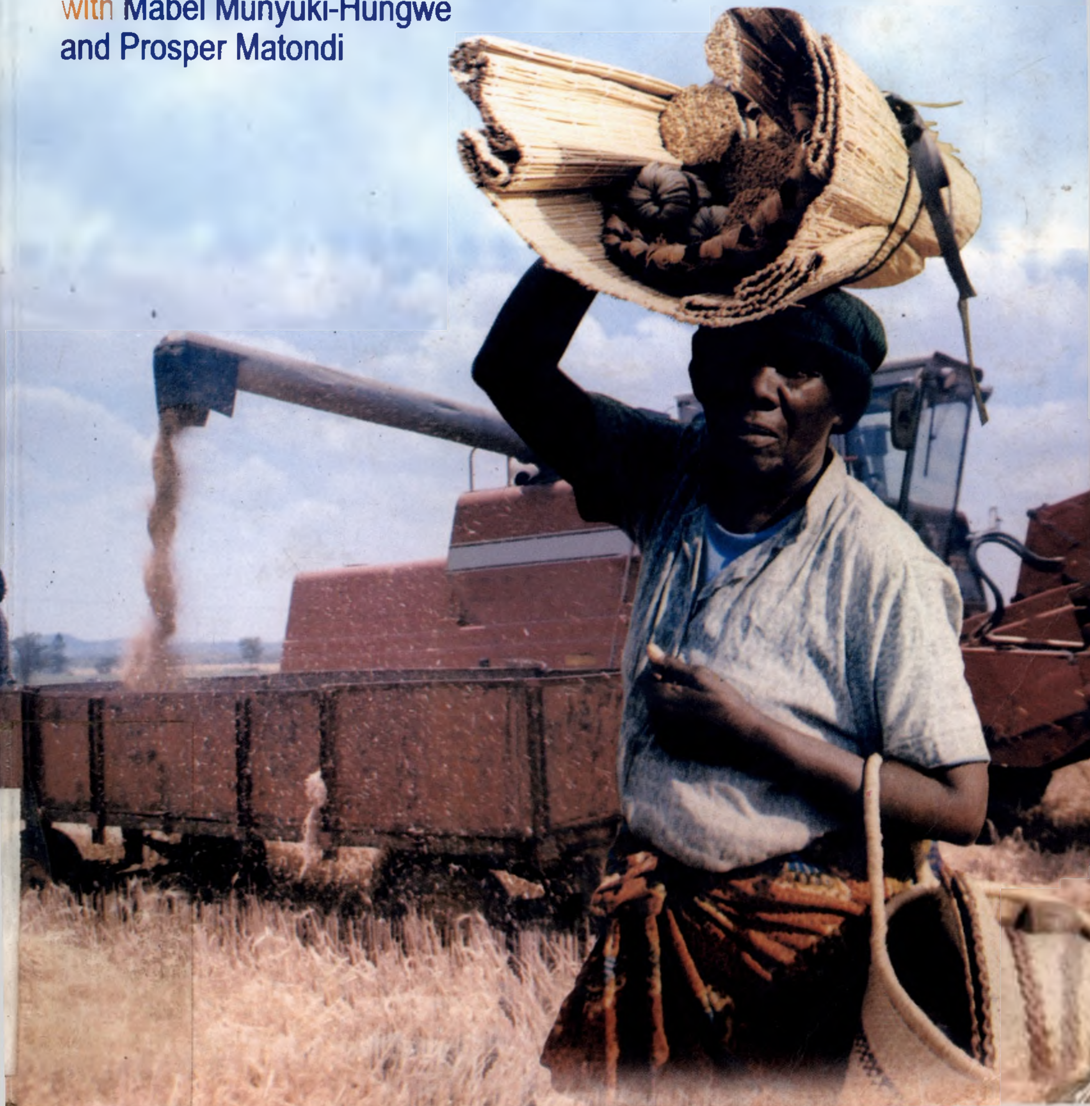

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PART IV THE AGRICULTURAL REVOLUTIONS
Introduction to Part IV 357

16 Maize research and development 363
Kingstone Mashingaidze
Maize production trends 363
The communal land maize production revolution 364
High-yielding cultivars (hybrids) 366
Support services 371
Issues facing the maize industry 373
Research needs 375
Conclusion 376

17 Cotton research and development: 1920 – 2004 381
Irvine K. Mariga
Historical perspective 382
Laying the research foundation 385
Genetic modification 388
Entomology research 388
Cotton pathology research 390
Weed research 391
Agronomy and physiology research 391
Developing support services 392
Understanding the smallholder cotton success story 394
Current issues 396
Conclusion 398

18 Tobacco research and development 403
Desirée L Cole and James S. Cole
Types of tobacco grown in Zimbabwe 404
Tobacco research 406
Information dissemination 412
Response to market opportunities 412
Stimulating smallholder production 412
Research and development: future needs 414

19 The growth and development of the horticultural sector 419
Stanley Heri
Overview 419
The growth and development of the horticultural sector 420
Smallholder sector 421
Large-scale commercial sector 424
Investment in greenhouse production 429
Production and quality strategy 429
Research and crop development 431
Horticultural exports 432
Conclusion 435

PART IV

THE AGRICULTURAL REVOLUTIONS

Maize production holds the key to food security – a maize bin in a communal area (National Archives)

16

Maize research and development

Kingstone Mashingaidze

Maize (*Zea mays* L.) ranks first in terms of the number of producers, area grown and total cereal production in Zimbabwe. Maize is the staple food crop of the nation and is also an important cash crop. About 64 per cent of Grain Marketing Board maize sales is used for human consumption, 22 per cent is used for livestock and poultry feed and 14 per cent is used for other industrial purposes. During good production periods, surplus maize is exported, earning much-needed foreign exchange.

Domestic consumers prefer white maize for their requirements although under emergencies, such as the droughts of 1966, 1992/1993 and 2001/2, people have had to change to eating yellow maize. Yellow maize is grown in Zimbabwe mainly for livestock feed and maize stover is an important source of livestock feed during the dry winter months. Therefore maize is a strategic crop for Zimbabwe and throughout eastern and southern Africa (Byerlee and Eicher, 1997). This chapter will first discuss the maize production trends in Zimbabwe and then examine the factors that have contributed to successful maize production in the different agricultural sectors. The chapter also explores the challenges for maize production in the new millennium.

Maize production trends

Maize production is a major enterprise on large-scale and small-scale farms. Smallholder farmers grow only white maize, retaining part of it for home consumption and selling the remainder. Large-scale commercial farmers used to grow maize mostly as a cash crop and grew both white and yellow maize. The national annual commercial requirements for maize are 1.8 million tonnes for human consumption and 500,000 tonnes for the strategic grain reserve kept by the Grain Marketing Board.

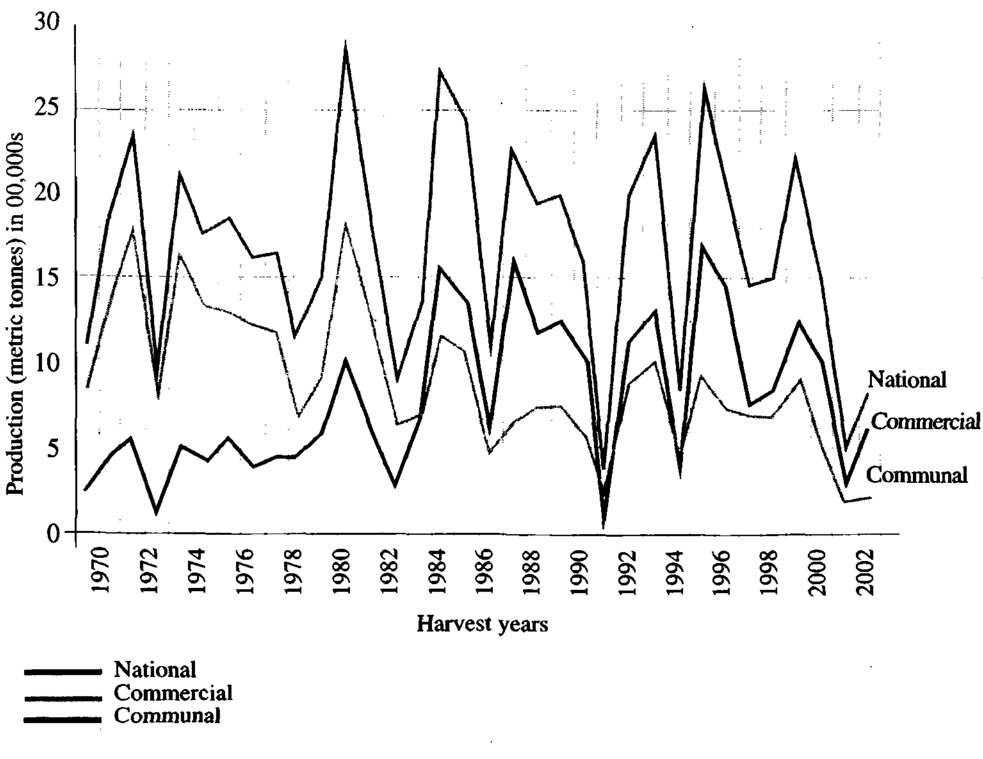
Maize production exhibits year-to-year variations according to rainfall (Wilson and Williams, 1974) so the maize industry has moved through great cycles of surplus and shortfall (figure 16.1). Three successive seasons of drought from 1981/82 to 1983/84 reduced maize production by about 70 per cent and Zimbabwe had to import maize. Production increased dramatically in 1985/86 and 1986/87 but maize imports were large in 1992/93 because of the worst drought in many decades. Zimbabwe also imported maize in 1997/98 and 1998/99 and Zimbabwe's maize production in the four seasons since 2000/01 have not been good, prompting food relief activities from the international community. Total production fell to 1.4 million tonnes in 2000/01 from the previous season and was only 498,000 tonnes in 2001/02.

The communal land maize production revolution

A significant feature in the national maize production scenario was the sharp post-independence increase in maize production by communal farmers (figure 16.1). Prior to 1980, large-scale commercial farmers produced approximately 80 per cent of the maize marketed through the Grain Marketing Board. The total communal, resettlement and small-scale commercial contribution to the Grain Marketing Board intake increased sharply from about 7.6 per cent in 1979/80 to about 60 per cent during the mid-1980s.

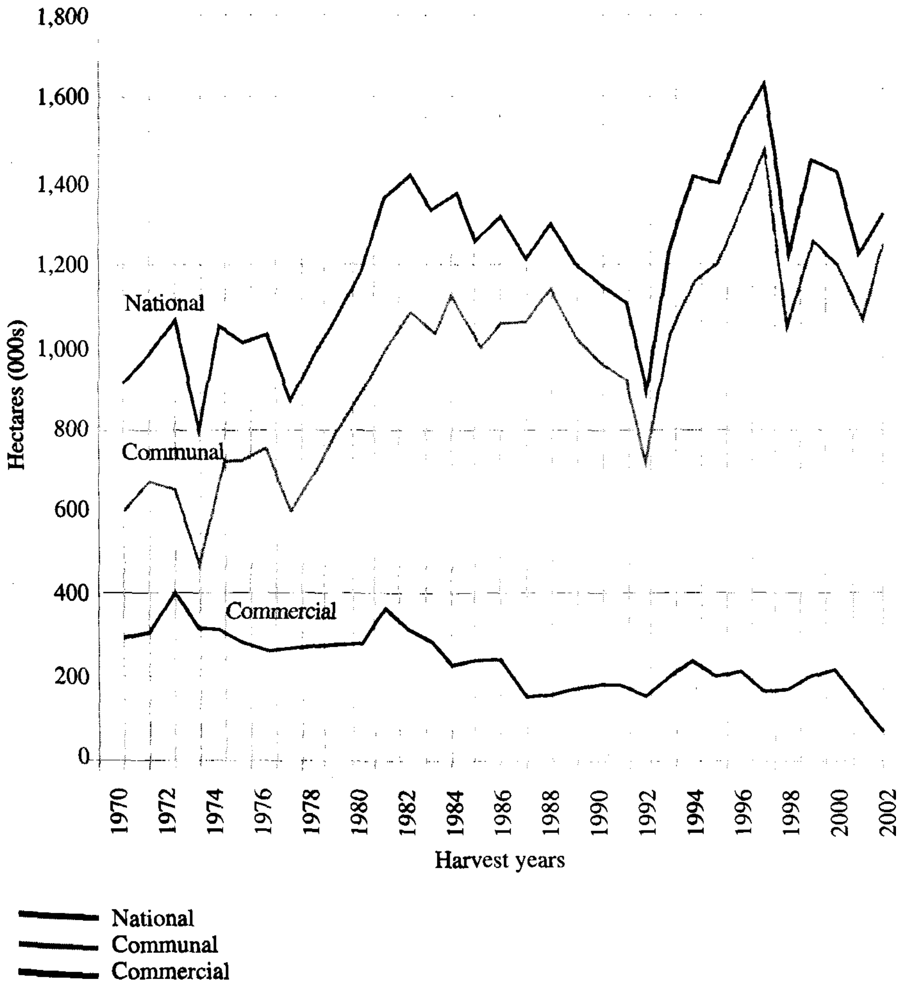
Communal land maize production surpassed large-scale commercial production in 1984 and this scenario was maintained in many seasons. After the

Figure 16.1 Maize production trends



1979/80 season, the Grain Marketing Board maize deliveries from the communal sector increased from 4.5 per cent to a record of 36.9 per cent in the 1985/86 season sales (following a good rainfall season) and continued to increase throughout the 1980s and 1990s. The factors responsible for the post-independence maize production revolution in the communal lands can be grouped into increase in area planted to maize, better maize yields and improved support services.

Figure 16.2 Area planted to maize 1970–2002



Growth in area planted

Most of the increase in communal land maize production in the first two years of independence resulted from the expansion in the area under maize because of the return of war refugees and returnees to their communal land homes. This resulted in a significant increase in the number of cultivators and the land under cultivation. After independence the new government embarked on a massive resettlement programme. Seventy-one thousand families were resettled on 3,498,440 hectares during the first land reform and redistribution programme (Tagwira, 2001). In 1997 the government embarked on the second land redistribution and resettlement programme with the aim of acquiring five million hectares of land from large-scale commercial farms and resettling at least 150,000 families.

Maize is the most cultivated crop in the small-scale farming sector, contributing about 50 per cent of the arable land in most years (Tagwira, 2001). Figure 16.2 shows the area cultivated to maize in the different sectors since 1970.

Increase in maize yields and support services

Maize yields increased significantly in the communal lands after 1980. Tattersfield (1982) reported that maize yields were about 0.7 tonnes per hectare in 1980 in the communal lands. The national average yield in 2004 was about 1 to 1.5 tonnes per hectare in predominantly dryland farming areas. The adoption of high-yielding technology, complemented by credit and input availability, and increased support services were mainly responsible for the sharp increases in communal land maize yields after independence.

High-yielding cultivars (hybrids)

Research into improving maize cultivars (varieties) was a key factor in increasing maize yields in Zimbabwe. Decades of intensive and sustained breeding work led to the development of an excellent range of locally-adapted maize hybrids for both low-rainfall and high-rainfall regions of Zimbabwe. Formal breeding research work dates back to 1909 when the testing of cultivars of numerous crops was started at Harare Research Station[175] (Weinmann, 1972 and 1975). Before 1932 the maize research programme was based on developing improved open-pollinated cultivars. The most widely grown cultivars were Salisbury White, Hickory King, Louisiana Hickory and Potchefstroom Pearl.

The breeding of hybrid maize was started at the Harare Research Station in 1932 using methods similar to those which were proving successful in the United

[175] Formerly known as the Botanical Experimental Station, then Salisbury Research Station.

States of America. Inbred lines were initially isolated from locally adapted, open-pollinated cultivars such as Salisbury White, Hickory King and Southern Cross. These cultivars were high-yielding and well adapted to Zimbabwe, and the initial inbreds from them were outstanding (Olver, 1988). For example, one parent of the hybrid SR52 was developed from a selection of Southern Cross, while the other inbred parent was derived from Salisbury White. The first experimental hybrids were tested in 1938 (Rattray, 1962). The first commercially-produced hybrid maize crop was in the 1948/49 season when a top-cross hybrid was grown. The first conventional hybrid SR1 (a double-cross[176] hybrid) was released for planting in the 1949/50 season.

Numerous experiments in various parts of the country demonstrated the superiority of hybrids over open-pollinated cultivars, particularly in poor rainfall seasons (Rattray, 1956; Robinson, 1956). For example, in the 1946/47 season when rainfall at Harare Research Station was 250mm below normal, the average yield of all experimental (single and double-cross) hybrids was 68 per cent higher than that of open-pollinated cultivars, compared with 50 per cent in 1945/46 and 32 per cent in 1947/48. The maize research programme, therefore, became hybrid-oriented and has remained so ever since.

Initially only double-cross hybrids were used in breeding because it seemed this was the only feasible method of producing maize hybrid seed economically. But the development of improved inbred lines coupled with improvements in management permitted the production of single-cross hybrids that were economically feasible for seed producers and farmers. The internationally-recognized single-cross hybrid SR52 was marketed in 1960, making Zimbabwe the second country (after the United States of America) in the world to introduce single-cross hybrid maize. SR52 became a very successful hybrid and was widely grown in the high potential areas of Zimbabwe, neighbouring countries and as far as West Africa and countries such as Cameroon. SR52 was a successful hybrid because it was developed from well adapted parents and, being a long-season cultivar, was well adapted to high-rainfall areas and responded well to high levels of management. It also possessed good agronomic qualities such as good standability and resistance to leaf and cob diseases.

Maize researchers in Zimbabwe initially focused on breeding cultivars suited to the high potential areas of Zimbabwe. The double-cross and single-cross hybrids that were released in the 1960s tended to be late maturing and were not suited to the marginal rainfall areas in natural regions III, IV and V which are characterized by short rainy seasons with frequent intermittent droughts. Maize is particularly susceptible to drought at pollination and during grain filling.

To develop cultivars adapted to marginal rainfall areas, researchers in the

[176] A double-cross hybrid is developed by crossing two single-cross hybrids; and a single-cross hybrid is developed by crossing two inbred lines.

1960s focused on developing short-season (early-maturing) heterogeneous hybrids. After extensive testing, short-season, three-way[177] hybrids R200 and R201 were released in the early 1970s. These offered qualities of drought escape and avoidance associated with early maturity, a long pollen-shedding period (of about 18 days), an excellent pollen-to-silk synchronization and tolerance to heat stress. These hybrids, particularly R201, proved successful and, until recently, were widely grown in the marginal rainfall areas of Zimbabwe. The highly successful early hybrids (R200, R201 and SR52) declined considerably in the late 1990s because of susceptibility to grey leaf spot (*Cercospora zeamaydis*), a major new disease in Zimbabwe.

In addition to the government maize breeding programme, a number of seed companies and organizations are actively involved in maize breeding in Zimbabwe (see chapter 10, Havazvidi and Tattersfield). These include the following:

- Seed Company of Zimbabwe (Seed Co, formerly Seed Coop), the largest and oldest seed company in Zimbabwe, until recently had a mandate to multiply and market all maize and other crop cultivars released by the national breeding programmes. Seed Co has its own well-developed maize breeding programme and enjoys the greatest market share;
- Pannar Seed (Private) Limited, a United Kingdom based seed company, started operating in Zimbabwe in 1981. It has a maize breeding programme based in South Africa and markets a number of locally adapted maize hybrids, of which PAN 473 has been popular with small-scale farmers;
- Pioneer Hi-Bred Zimbabwe (Private) Limited, a local company of Pioneer Hi-Bred International, which is the largest seed company in the world, started operating in Zimbabwe in 1985;
- Cargill started operating in Zimbabwe in 1988 and its maize breeding licence was bought by Monsanto (registered as Monsanto Zimbabwe) in 2000. The Cargill-bred hybrid CG 4141 is also popular with small-scale farmers. Monsanto Zimbabwe is championing the need to develop and market genetically modified maize hybrids;
- CIMMYT-Zimbabwe, the regional centre of the International Maize and Wheat Improvement Centre (CIMMYT) based in Mexico, started operating in Zimbabwe in 1984. It provides improved maize germplasm to national and private sector breeding programmes. It has developed a wide range of inbred lines and open-pollinated maize experimental cultivars with resistance to or tolerance for drought, low nitrogen and common pests and diseases. The national breeding institute recently released two open-pollinated maize cultivars (ZM421 and ZM521) developed by CIMMYT-Zimbabwe for production in the small-scale farming sector;

[177] A three-way hybrid is developed by crossing a single-cross hybrid and an inbred line.

- The African Centre for Fertilizer Development, in collaboration with Africa University, are developing brachytic-2 dwarf maize hybrids with dark green leaves, normal-sized cobs and short plant height.
- Two dwarf hybrids (AC31 and AC71), marketed by Agricura (Private) Limited, have been on the market since 1999 and are quite popular with small-scale farmers.

The maize breeding programmes in Zimbabwe have been successful over the years and have benefited small-scale, medium-scale and large-scale farmers (Eicher, 1995). A wide range of maize (single-cross and three-way) hybrids are available for commercial production. Medium-term and late maturing hybrids are recommended for production in the high rainfall areas and early maturing three-way hybrids are recommended for production in the marginal rainfall areas. Early maturing, single-cross hybrids have not been successful in marginal rainfall areas despite their higher yield potential because they are too susceptible to drought.

Commercial farmers rapidly adopted maize hybrids. The area planted to hybrids on white-owned farms increased from 22 per cent in 1949/50 to 88 per cent in 1960/61 and 93 per cent in 1966/67. Although adoption was slower in the communal lands, many farmers adopted hybrid seed before 1980. For example, in Mangwende communal land, about 42 per cent of maize producers had adopted maize hybrids in 1975. Five years later the proportion had risen to 77 per cent and by 1985 about 99 per cent purchased hybrid seed (Rohrbach, 1987).[178] All maize grown by the former large-scale commercial farming sector used to be planted to hybrids. About 90 per cent of the communal land maize hectarage is planted to hybrids, with the balance being planted to other forms of seed, including recycled seed. The demand for hybrid seed in the communal lands has grown to the extent that 80 per cent of maize seed is bought by this sector.

The yield gains attributable to the use of hybrids per se were estimated to be about 46 per cent in the large-scale commercial farming sector (Tattersfield, 1982) and 30 per cent in the communal lands. Farmers growing hybrids benefited from the use of good quality seeds by achieving good plant stands and high yields. Under good management, the heterogeneous three-way hybrids achieve higher yields than open-pollinated cultivars even in drought years.

Seed availability

Zimbabwe has an advanced seed industry. Until 2001, Seed Co had the sole right to multiply and market maize hybrids developed by the national breeding

[178] In Chivi South communal area, about 50 per cent of the maize producers had adopted hybrids by 1975, about 90 per cent in 1980 and 100 per cent in 1985 (Rohrbach, 1987).

programme. It had the responsibility to produce adequate quantities of high quality certified seed to meet local requirements and a provision of 20 per cent stock. Seed Co efficiently produced and distributed hybrid maize seed and farmers never experienced a shortage of high quality maize seed. Seed Co's monopoly to market maize hybrids developed by the national maize-breeding programme was terminated by the government in 2001. This move was not likely to have any negative effect on seed availability because of the large number of seed companies already competing on the Zimbabwean market. Seed is distributed in two, five, ten, twenty-five and fifty kilogram packages throughout the country. However, the advent of the fast track land resettlement programme introduced a new challenge in maize seed production. Thus, the increased demand for maize seed due to increased numbers of farmers versus a reduced maize production base led to maize seed shortages in recent cropping seasons. The increased demand has however been complemented by imports by the donor community supporting agricultural recovery programmes.

Agronomy

Maize is one of the most heavily researched crops in Zimbabwe. Just as for breeding, the agronomic recommendations for maize production were developed locally by local agronomists. The bulk of the agronomic research by the former Department of Research and Specialist Services during the colonial period was aimed at the high rainfall areas (natural region II) of the country where maize was produced by commercial farmers. Nevertheless, many of the research findings are also applicable to the drier areas of the country (Metelerkamp, 1987).

Many trials to establish optimum pH levels (and hence lime requirements) and response curves to nitrogen, phosphate and potash have been carried out on all the major soils of Zimbabwe. Soil analyses procedures, particularly for nitrogen and phosphorus, have been developed and calibrated for local conditions.[179] Considerable research has also been conducted to establish the soils and conditions under which trace element deficiencies or toxicities and nutrient imbalances are likely to occur (Soane and Saunder, 1959).

Nitrogen is by far the most important nutrient in maize production in all areas of Zimbabwe. Yields in good seasons are directly correlated with available soil nitrogen (Saunders, 1956). Tattersfield (1982) reported a more than threefold increase in maize yields in the commercial sector from 1,146kg per hectare between 1946 and 1950 to 4,726kg per hectare between 1976 and 1980. About 62 per cent of this increase was estimated to be due to the use of nitrog-

[179] The fertility of individual soils for maize production can be assessed with a fair measure of precision and, within the limits imposed by climatic variations, suitable fertilizer applications can be predicted.

enous fertilizer and the balance represented the use of increased plant populations (6 per cent), early planting (5 per cent), weed control (9 per cent), pest control (3 per cent) and early harvesting (2 per cent). Most fertilizers (compounds and ammonium nitrate) are locally manufactured (see chapter 12, Rusike and Sukume). These are constituted to match local soil types and crops. Phosphate fertilizer is locally produced while potash requirements are imported.

Support services

Hybrid maize research fuelled Zimbabwe's agricultural revolution but it was only effective because it was reinforced by a range of support institutions and a favourable policy environment. The next sections shall examine how these support services have complemented maize research.

Extension

Agricultural extension is the responsibility of the Ministry of Lands, Agriculture and Rural Resettlement and this mandate was carried out through the Department of Agricultural, Technical and Extension Services. In 2001, the Department of Agricultural, Technical and Extension Services merged with the Department of Research and Specialist Services to form a new Department of Agricultural Research and Extension (AREX).[180] Extension policy after independence emphasized support to the communal lands and increased the number of village-level extension workers. The extension worker to farmer ratio narrowed from 1:1000 in 1980 to about 1:800 in 1990.

Through a World Bank loan, the Department of Agricultural, Technical and Extension Services embarked on a number of activities to strengthen the effectiveness of extension in communal lands. Increased extension support has played an important role in the adoption of high-yielding technologies. Several non-governmental organizations and seed and chemical companies have also speeded up the adoption, timing and consistency of input-use by running programmes such as *Kohwa Pakuru*[181] and annual competitions. All seed companies conduct a large number of on-farm trials and demonstration plots and hold field days in the communal lands.

Marketing

Prior to 1980 the Grain Marketing Board built marketing depots on the line-of-rail in the commercial farming areas but only three were built in communal lands. Ten new depots were built in communal lands between 1980 and 1985.

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[180] See chapter 9 on agricultural extension.

[181] *Kohwa Pakuru* (meaning 'large harvest') was a project launched by a private agro-chemical company, Ciba-Geigy, and involved promotion of seed and chemical packages for smallholder farmers.

The Grain Marketing Board had also built 55 buying (collection) points by 1985 (of which 13 were mobile), allowing better market access to communal land farmers. The expanded market infrastructure, coupled with nominal increases in the maize price, played a significant role in stimulating communal land maize production and sales to the Grain Marketing Board. For example, Grain Marketing Board receipts from Mangwende communal land tripled in 1981, doubled in 1982 and grew by another 50 per cent between 1982 and 1985 (Rohrbach, 1987).

Credit

The increase in maize deliveries by the communal land producers to the Grain Marketing Board was partly attributable to increased access to credit. In 1978, the Agricultural Finance Corporation (now Agribank) launched a small-farm credit scheme for communal land farmers. This facility was targeted for expansion at independence. The Agricultural Finance Corporation loans were for designated input packages which included seed, fertilizer and insecticides. Most credit was allocated for maize and cotton production. The Agricultural Finance Corporation maize package in natural regions III and IV included 200kgs compound D (8N: $14P_2O_5$: $7K_2O$) and 200kg ammonium nitrate (34.5 per cent N) fertilizers, 20kg seed and 2kg Dipterex per hectare. Farmers who received credit purchased more than twice as much fertilizer as farmers purchasing fertilizer without credit (Rohrbach, 1987).

Following the semi-privatization of the Agricultural Finance Corporation and uncertainty of the government-sponsored Agricultural Development Assistance Fund, the Grain Marketing Board in 2000 managed an input credit scheme at 20 per cent interest rate to smallholder farmers for cereal grain production. The Grain Marketing Board scheme was funded by government through the Ministry of Lands, Agriculture and Rural Resettlement. Farmers who qualified for the loan collected inputs (seed, fertilizer and pesticides) from Grain Marketing Board depots. In an effort to reduce the default rate in loan repayment, the Grain Marketing Board scheme in the 1990s was based on group lending and its officers worked closely with the Department of Agricultural, Technical and Extension Services officers. Farmers could pay back the loans in the form of grain to the Grain Marketing Board. This framework has, however, been disrupted by droughts that have tended to create high default rates.

Pricing policy

Crop producer prices are announced by the Minister of Agriculture each year. In 1980 maize was imported for the first time since 1966. In an attempt to boost confidence and production, the government announced a guaranteed pre-planting price of Z$120 per tonne, a 50 per cent increase from the previous year. Combined with a good rainy season, maize production increased by 147 per cent in 1980/81 with the largest increase coming from the communal lands.

Issues facing the maize industry

The decline in maize production (grain and seed) in the commercial farming sector

The commercial sector maize production has generally experienced a decrease from the 1980s up to 2005. For instance, the production base declined from 280,000 hectares in the 1980/81 season to 110,000 hectares in 1990/91 and slightly increased to 121,000 hectares in 1999/2000. The main causes have been the official policy of encouraging diversification into other commodities such as horticulture and oilseeds; the declining real producer prices and acquisition of large-scale commercial farms for resettlement.

In 1986 Zimbabwe had a maize stockpile of about 1.8 million tonnes (equivalent to two years' supply). The Grain Marketing Board was faced with a huge deficit because of storage costs. Neighbouring countries lacked foreign exchange to import maize from Zimbabwe. As a result the government imposed maize production restrictions in 1986 and called upon the commercial producers to diversify into oilseed crops.

Without question, the profitability of maize production has declined despite recent nominal increases in producer prices from Z$215 per tonne (1988/89), Z$270 (1990/91), Z$950 (1995/96), Z$1,200 (1997/98), Z$4,200 (1998/99), Z$7,500 (2000/01) to Z$15,000 (2001/02) and Z$750,000 (2002/03). These increases were cancelled out by corresponding increases in input costs, particularly costs of labour and fertilizer. At present maize has lost its competitiveness and there is a need to increase economic incentives. In an attempt to build up the strategic reserve held by the Grain Marketing Board, the government in July 2001 reintroduced marketing controls and made maize a controlled product (to be sold only to the Grain Marketing Board within 14 days of harvesting). Such a move was likely to drive more farmers out of maize production.

The 2002/03 and 2003/04 planting seasons were severely affected by maize seed shortages. Whilst commercial sales of hybrid maize seed fluctuated between 28,000 and 32,000 tonnes before the fast track land reform and resettlement programme, demand for hybrid maize seed was estimated at over 50,000 tonnes. The fast track land reform and resettlement programme period has seen a significant drop in seed production in the face of increasing demand. Reduced hybrid maize production was due to acquisition of seed producing farms. Although a number of the newly resettled farmers have taken up seed production, meeting the increased demand will take some time. The newly resettled farmers faced a number of problems including lack of resources to establish irrigation facilities, a prerequisite in hybrid maize seed production.

Drought

Maize is a high-risk crop because it is susceptible to drought. About 90 per cent of communal lands are in natural regions III, IV and V, which are marginal for maize production (Whitlow, 1979). Furthermore, about 82 per cent of the land acquired for the first land resettlement programme was in natural regions III to V (Tagwira, 2001). Zimbabwe has experienced a number of droughts since 1980 which affected the maize production base negatively. The droughts of the 1980s and 1990s showed how vulnerable Zimbabwe's maize production base was to drought. Since the country depends on communal sector farmers for maize deliveries, there is need to address the issue of drought vulnerability.

Development of irrigation infrastructure needs to be speeded up as this is the only way of reducing the dependency on rainfall. The old irrigation schemes need to be rehabilitated and managed more efficiently. Also, farmers in marginal rainfall areas should be encouraged to grow more drought-tolerant cereal crops such as sorghum and millets.

Low maize yields

Yields have increased sharply since 1980 but they are still low and variable. The national average yields in communal lands are about 1 to 1.5 tonnes per hectare compared with about 5.0 tonnes per hectare in the former commercial farming sector. The major factors limiting maize yields in the communal lands are: drought; poor soil and fertilizer management; low plant populations; late planting; poor weed control; labour shortages; and insufficient inputs and draught power (Shumba, 1984; Mataruka, 1985; Mataruka and Whingwiri, 1988).

Most of these yield-limiting factors could be overcome with better management. It should be possible to double yields in the communal lands by using recommended high-yielding technologies. More emphasis should be placed on increasing extension and credit support to the communal lands. There is limited and constrained accessibility of agricultural inputs by communal sector farmers due to lack of finance. On average, smallholder farmers applied 50kgs fertilizer per hectare compared to 550kgs per hectare by former commercial farmers. The Grain Marketing Board input scheme has been highly inadequate and fertilizer companies are unable to meet demand due to a shortage of foreign exchange to import the necessary fertilizer ingredients, and the prices of fertilizer are also inhibitive.

Maize yields in the resettlement areas (1.5 to 2 tonnes per hectare) are slightly better than those obtained by communal area farmers but still much lower than those previously obtained by commercial farmers. Their slightly better yields are attributable to the better state of the land compared with the fragile and exhausted soils in the communal areas (Tagwira, 2001). Most resettled farmers are using the same poor farming methods which they used in the communal lands. Thus, the yields obtained by resettled farmers are not sustainable unless adequate levels of fertilizer and other technologies are used.

Research needs

There are a number of areas where further research is required to improve and stabilize maize production, particularly in the communal sector.

Maize breeding

Drought is one of the major factors limiting maize production in the communal sector. There is need to breed more stable early-maturing maize cultivars better suited to the drier areas of the country. Cultivars should possess qualities such as early maturity, prolificacy and good silk-to-pollen synchronization. Such cultivars should be either heterogeneous three-way hybrids or open-pollinated. Research trials in communal areas have shown no yield differences between hybrids and open-pollinated cultivars under marginal conditions. The government recently introduced a policy to promote the development of open-pollinated cultivars by the national programme. Open-pollinated cultivars should be developed in order to give farmers economically viable choices.

Most maize cultivars currently recommended for production in natural regions III to V are three-way hybrids and are stress tolerant due to population buffering rather than individual plant resistance. There is a need to develop maize cultivars with drought tolerant (resistant) plants. The role of biotechnology in increasing the efficiency of selection cannot be overemphasized. The maize project on molecular marker assisted selection for quantitative *trait loci* (for pest and drought tolerance) being conducted by the Scientific Industrial Research and Development Centre should be expanded and emulated by all maize breeding programmes.

Prolificacy is the ability to produce more than one seed-bearing cob per plant. A prolific cultivar is expected to produce at least one good cob under stress conditions and two cobs under normal rainfall and low plant population conditions. Prolificacy is also associated with good pollen-to-silk synchronization and stress tolerance (Motto and Moll, 1983).

Most communal area farmers plant some of their maize crops late because of lack of draught power to plant the whole maize crop with the first planting rains. Also, staggered planting helps spread the risk. None of the current hybrids are suitable for late planting so there is need to develop maize cultivars with a sufficiently short cycle of development (100 to 120 days to physiological maturity) suitable for late planting. There is also need to develop hard endosperm maize types (such as flint hybrids) which are suitable for on-farm storage.

Nitrogen is the major nutrient limiting maize productivity in Zimbabwe. Most soils in the communal lands are granite-derived sands and are inherently infertile. Most communal farmers cannot afford to use the recommended fertilizer levels because of lack of credit. Research should, therefore, develop maize cultivars that can give high and stable yields under low nitrogen levels. CIMMYT-Zimbabwe has made a lot of progress in this area.

Agronomy

There is need for research on moisture-conservation techniques such as: tied-ridges and potholing to harvest rainfall; stubble mulching to increase water infiltration and reduce runoff and soil erosion; early post-harvest ploughing (winter ploughing); and keeping the ploughed land weed-free. Because of the low water-holding capacity of soils in Zimbabwe, the use of tied ridges or potholing should be coupled with the application of manure or ploughing-in crop residues in order to increase the water-holding capacity of the soil.

Most farmers depend on cattle for draught power. The cattle herd is an integral part of the subsistence economy and provides inputs of draught power and manure for crop production with beef sales being secondary. But the number of farmers is increasing at a faster rate than the increase in cattle population. Severe droughts have decreased the number of farmers with cattle. The draught-power problem is exacerbated by the lack of dry-season cattle feed, resulting in a weak and reduced draught power at the start of each season. Research is needed on effective and economic ways of maintaining oxen and donkeys in good condition throughout the year, particularly during the dry season. Research should seek ways of cutting down the number of tillage operations before planting. Ploughing normally starts with the first rains and progresses very slowly. Some farmers plant maize as late as January. Minimum tillage should enable earlier planting.

Conclusion

Maize is the staple food crop as well as a cash crop in Zimbabwe. The maize, cotton and tobacco industries have been the engine of development in Zimbabwe and have raised rural incomes and generated employment and foreign exchange. Maize is susceptible to drought and its production varies widely depending on the season. A significant feature after independence was the dramatic increase in maize production in communal lands which produces approximately 60 per cent of the maize delivered to the Grain Marketing Board.

Research on hybrid maize varieties has been a strategic factor (a prime mover) in increasing maize yields. An excellent range of locally-developed and adapted hybrids was made available to farmers. The maize production revolution among communal area farmers was supported and facilitated by a range of public and private service institutions, the expansion of Grain Marketing Board buying points, and a positive pricing policy, especially in the first half of the 1980s. The major challenges facing the maize industry are drought, high input costs (particularly seed and fertilizer), transport problems and lack of profitability. Extensive research results covering all aspects of maize production are available. Although most of the research was conducted in the high rainfall areas and was aimed at meeting the needs of commercial farmers, most of the results are applicable to the communal sector located in marginal rainfall areas. Research is necessary to develop the following:

- More drought-tolerant, short season heterogeneous hybrids and open-pollinated cultivars;
- Cultivars with high nitrogen-use efficiency; and
- Practical recommendations on minimum tillage and moisture-conservation techniques, in order to increase and stabilize maize yields.

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